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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Plant Disease Epidemics and Identification Section serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

THE PLANT DISEASE REPORTER

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PLANT DISEASE EPIDEMICS AND IDENTIFICATION SECTION

Horticultural Crops Research Branch — Plant Industry Station, Beltsville, Maryland
Volume 39 — May 15, 1955 — Number 5

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DISEASE DEVELOPMENT AND SEASONAL SUCCESSION OF PATHOGENS OF WHITE CLOVER
PART II -- STOLON DISEASES AND THE DAMAGE-GROWTH CYCLE

Kenneth H. Garren[1]

Introduction

This report has been presented in two parts to emphasize the ecological nature of the sequential relationships among societies of fungi pathogenic on white clover. Part I (Plant Disease Reporter 38: 579-582. 1954) established the general background of the study, gave details on procedure, and presented a discussion of the fungi attacking leaf tissue. The diagrams in Part I showed that the damage attributed to stolon-attacking fungi was greater than that attributed to leaf fungi. Separation of the damage into three maxima was shown, two for leaf damage and one for stolon damage.

Results

During the period February through April no measurable defoliation could be attributed to stolon-attacking fungi. The maximum vegetative growth-rate was 24 pounds of additional dry matter per acre per day in mid-April, and the maximum flowering was 32 flowers per clonal planting in early May. Stolon damage became evident in May, increased rapidly during June and July, and reached a maximum of 68 percent defoliation early in September. There was an inverse correlation between flowering-vegetative growth of white clover and stolon damage (Fig. 1). The diagrams in Figure 1 emphasize the greater importance of the damage attributed to stolon pathogens. The maximum defoliation that resulted from stolon damage was about twice as great as either the leaf-damage maximum in May or the secondary leaf-damage maximum in January.

In preliminary analyses the most evident damage-environment relationship was between stolon damage and maximum temperatures. The maximum temperatures for late May through June, 1953, were unusually high for the Auburn, Alabama area. The maximum of 96° F. in May 1953, was 10 degrees higher than the maximum under identical circumstances in May 1954. This period of unusually high temperatures in 1953 was followed by a rapid increase in the amount of stolon damage (Fig. 1).

Usually, 50 percent or more of the isolates from damaged stolon tissue were Fusarium spp. and Rhizoctonia solani Kuehn. Other fungi isolated less frequently were Sclerotium bataticola Taub., S. rolfsii Sacc., Alternaria tenuis Auct., Curvularia trifolii Bon., Colletotrichum graminicola (Ces.) G. W. Wils., and Pythium spp. The data on isolated fungi were scaled to represent that portion of the defoliation that could be attributed to each fungus. The results of this scaling are presented in Figure 2. The maxima were 30 percent for Rhizoctonia in late August and 40 percent for Fusaria in late September. There was no evidence that any of these stolon fungi entered through decaying or damaged roots.

Debility appeared to be a minor factor in stolon damage. In January enough Alternaria tenuis was isolated from dying stolon tissue to account for about 1.5 percent defoliation. Thus very little damage could be attributed to cold-induced debility. During the summer, bacteria were islated from dry-rotted stolons. Undoubtedly the rot followed sun-scald and the maximum defoliation from this type of debility was 8 percent in early September (Fig. 2).

Discussion

The clover plants were set in the fall of 1952 and considerable vegetative growth occurred before there was an appreciable amount of stolon tissue subject to disease. The stage of growth of clover may account, in part, for the inverse correlation between flowering-vegetative growth and stolon damage. The close parallel in time between the period of the greatest rate of increase in stolon damage and the period of gradual but marked decrease in vegetative growth (Fig. 1) suggests a possible interrelationship. The defoliation resulting from pathogens

[1] Formerly Associate Professor and Associate Plant Pathologist, Department of Botany and Plant Pathology, Alabama Polytechnic Institute, Auburn, Alabama; present address, Vegetable Crops Section, Horticultural Crops Research Branch, Agricultural Research Service, Tidewater Field Experiment Station, Holland, Virginia.

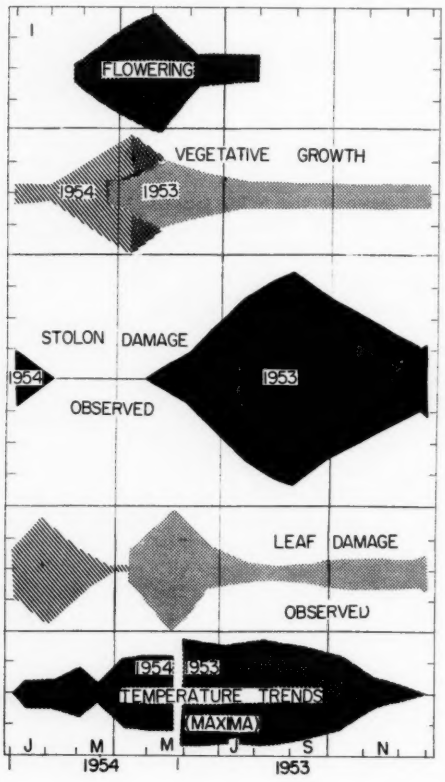

FIGURE 1. Interrelationships of flowering, vegetative growth, temperature, stolon damage and leaf damage in white clover.

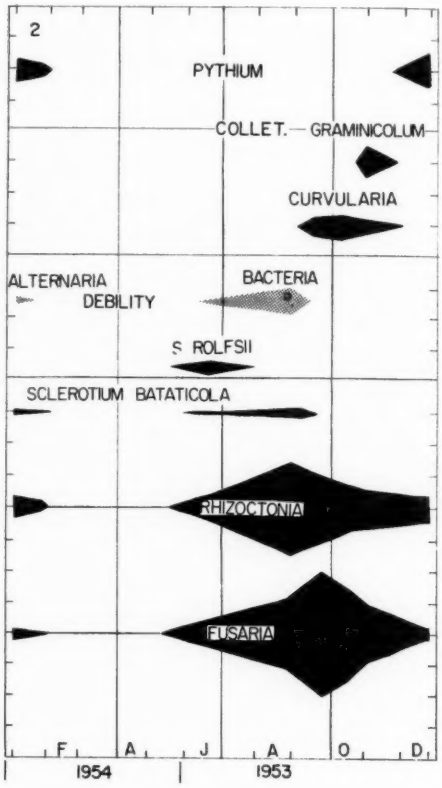

FIGURE 2. Seasonal succession and societies of fungi pathogenic on white clover stolons.

attacking stolons was greater, in terms of both total damage and maximum damage, than that resulting from leaf fungi (Fig. 1). Rhizoctonia and Fusaria, then, were considerably more important in causing damage than all of the other leaf-and stolon-attacking fungi. The rapid increase in stolon damage during a prolonged period of high temperatures (Fig. 1) suggests that heat injury may be a predisposing factor.

Successional societies were not so clear-cut among stolon-attacking fungi as among leaf-attacking fungi. Instead, there was a preponderance of Rhizoctonia and Fusaria and less activity by stolon-attacking fungi during the winter months. It is apparent from Fig. 2, nevertheless, that the fungi attacking stolons comprised two successional societies. One of these consisted of Rhizoctonia and Fusaria with Sclerotium rolfsii and S. bataticola in minor roles. The other group, Curvularia, Colletotrichum graminicola, and Pythium, comprised a "medium temperature society" of relatively minor importance.

There were five societies of fungi active in the stolons and leaves of white clover:

(A). The High-Temperature Society. Curvularia and Colletotrichum graminicola on leaves and Rhizoctonia and Fusaria on stolons.

(B). The Low-Temperature Society. Pseudoplea, Stagonospora, and Sclerotinia. Active on leaves only.

(C). The All-Year Society. Colletotrichum destructivum and Stemphylium. Active on leaves only.

(D). The Medium-Temperature Society. Curvularia, Colletotrichum graminicola and Pythium. On stolons only.

(X). Debility Indicators Society. Alternaria and saprophytic bacteria.

The damage caused by the high temperature society did not reach a maximum until the onset of medium temperatures in September. Some damage from both societies was evident in the period of lowest temperatures. There was no similar lag of damage behind associated temperatures for leaf-attacking societies. (See Part I.).

THE DAMAGE-GROWTH CYCLE

This report is based on a study of a stand of white clover that had been hand-set from pot-grown propagules on soil treated with a nematocide. Disease records were not taken until the stand was well established under conditions typical of a young, well-managed pasture. The basic concepts derived from this study might apply to similar clover stands. The greater importance of stolon damage attributed to Rhizoctonia should not be so overemphasized that the consequence of damage by leaf fungi is minimized. Part I of this report showed that during the time of little or no damage to stolons there was considerable damage from leaf fungi and debility. Also, the maxima for leaf damage occurred just before and just after the period of maximum vegetative growth. These and several other sequential relationships shown by the diagrams fit together into a damage-growth cycle, which may be summarized:

1. Period of Debility. January to mid-February. Defoliation during this period was largely due to cold induced debility (society X), but some damage resulted from two societies attacking leaf tissue only, the all year society (C) and the low temperature society (B).
2. Period of Maximum Vegetative Growth. Mid-February through April. A period of continued but minor activity by the all-year and the low-temperature societies. Considerably more growth of foliage than defoliation.
3. Static Period. May and June. Vegetative growth still good, but slowed by flowering. The beginning of activity of the high-temperature society (A).
4. Period of Maximum Defoliation. July through October. A period of high temperatures and erratic precipitation. Continued growth but approximately twice as much defoliation as growth. The high-temperature society (A) was extremely active at this time.
5. Transition Period. November and December. Many changes, some difficult to measure or represent. Continued activity by the high-temperature and the all-year society with peak activity for the medium-temperature society (D). The low-temperature society (B) began activity during this period. Defoliation continued, but decreased gradually. Clover seedlings became established in areas denuded by disease during the summer, but no measurable increase in vegetative growth occurred. The formation of new foliage by seedlings was approximately balanced by defoliation, mostly of the original plants.

The end of the transition period is also the end of both a damage-growth cycle and a calendar year. Further and more intensive study might reveal the major variations from this cycle, the differences in make-up of the societies, the effect of increase in nematode populations, and the results of genetical mixing in the seedlings.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, ALABAMA POLYTECHNIC INSTITUTE, AUBURN, ALABAMA

PAPERS FROM THE SYMPOSIUM ON FORAGE CROP DISEASES AND GRASSLAND FARMING

presented at the Louisville meeting by
Southern Division, American Phytopathological Society and Southern Branch,
American Society Agronomy (Crops Section)
Louisville, Kentucky, February 7-9, 1955

GRASSLAND FARMING A CHALLENGE TO EVERYONE

By Karl D. Butler

The United States of America can be compared to a great estate of about 2 billion acres. Of this, 1.2 billion acres are in farms, 415 million acres in grazing lands, and 475 million acres in cropland. Although this is a young country the acreage in cultivated cropland has remained approximately the same for over three decades, with a deviation of less than 2 percent one way or the other. Irrigation and reclamation projects have just about kept even with the pushing out of towns and cities into rural areas and the shift in other land back into timber and grassland.

Of the 368 million acres of cropland harvested annually, approximately 10 percent is used for cotton, sugar and other specialized crops, 20 percent for the production of food crops for direct human consumption and the remaining 70 percent to produce feed for livestock. Although the over two-thirds of our farm land that is devoted to grass forms the basis for the greater part of our agriculture, grass is of no direct value for human consumption and must be processed through poultry and livestock into meat, eggs, butter, cheese and other products. This type of agriculture often is referred to as animal agriculture. Call it what you will, grassland farming is the lush green carpet upon which our present-day agriculture is built.

Grassland farming has spread rapidly throughout the South. For years Southern farmers fought grass -- fought it in the cotton fields and almost everywhere -- but during the last 15 years, the real story on grassland farming in America has largely been written south of the Mason-Dixon line. During this period over 75 percent of all of the new pasture seedings in the United States were planted in the 13 Southern States and account for 30 million new acres of pasture. In 1954 approximately 80 percent of all the new grass seedings in the United States were made in the South.

Today in agriculture we need the combined ability, training, and experience of all plant scientists to bring about the team play that will make it possible for a better tomorrow. The continual advance of grassland farming as a means to this end is a challenge to everyone.

AVCO MANUFACTURING CORPORATION, ITHACA, NEW YORK

SOIL-BORNE PATHOGENS OF GRASSLAND CROPS

By Howard W. Johnson

The legumes and grasses grown for forage in the South are subject to attack during various stages of their life by soil-borne parasitic fungi. The parasites are favored during the early stages of the development of the host plants, since the seeds germinate in moist soil where the fungi are present. The diseases that occur in these stages are known commonly as pre-emergence rots, damping-off, and seedling blights. Such diseases frequently make difficult the obtaining of a satisfactory stand. Later in the life of the host plants, whether in pure or mixed stands, the herbage forms mats of foliage which tend to keep the humidity high. This condition favors the development of diseases known as root, crown, and foot rots. The common soil-borne pathogens are Fusarium spp., Pythium spp., Rhizoctonia spp., Sclerotinia trifoliorum, Sclerotium batatícola, Sclerotium rolfsii, and Leptodiscus terrestris.

The important effects of the non-living factors of the soil and aerial environment upon the development of soil-borne diseases has long been recognized. More recently, it has been realized that disease development is affected by other soil micro-organisms, as well as by the behavior of the primary parasite concerned. The fungus causing the disease is followed rapidly into the host tissues of infected roots by other micro-organisms, with which it must thereafter be associated. Therefore, once the primary parasite responsible for the production of a root disease has been determined, experimentation should no longer be restricted to work with pure cultures of the parasite introduced into sterilized soil. Other experiments should be carried out in non-sterilized soil, under conditions permitting full play of the microbiological factor.

Control measures for soil-borne diseases of field crops may be classified under the following headings: 1) the production of disease-resistant varieties, 2) crop rotation, 3) plant sanitation, and 4) control under the growing crop.

FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE AND MISSISSIPPI AGRICULTURAL EXPERIMENT STATION, STONEVILLE, MISSISSIPPI

VIRUS DISEASES OF GRASSLAND CROPS

By K. W. Kreitlow

Earlier reports concerning occurrence of virus diseases on grasses and legumes were principally of academic interest. With more intensive cultivation and study of improved forage crops, it is now becoming increasingly evident that virus diseases play a role of major importance.

Because they are systemic, viruses can be killers or they can become chronic in a plant. If a virus infection does not kill the host prematurely it frequently weakens the plant so that it cannot withstand adverse conditions such as summer drought or winter injury. Two characteristics of grassland viruses that make them potentially dangerous are their broad host range and rapid means of spreading. For example, strains of alfalfa mosaic virus occur in and damage such widely divergent hosts as Ladino clover, potato, celery, pepper, bean, pea, and a number of weeds. The virus survives in perennial hosts during unfavorable periods of summer and winter. Insects feeding on such infected hosts early in the spring carry the virus to different kinds of plants as each develops. Thus a succession of different crop plants including forage legumes can comprise the chain for perpetuating and increasing the virus.

Alfalfa mosaic virus is one of a group of viruses that attack Ladino clover, one of our most valuable forage legumes. Research conducted at Beltsville, Maryland, indicates the predominant viruses involved are several different strains of alfalfa mosaic and bean yellow mosaic. In a field nursery of 3,000 plants screened for potential resistant material, only two plants were found free of virus. These plants have been increased clonally for field tests and for artificial inoculation with various strains of alfalfa mosaic and bean yellow mosaic viruses to determine their resistance to infection.

During the past several years a destructive and rapidly spreading virus epidemic has occurred on sweet yellow lupine in the southeastern United States. Many fields of yellow lupine were infected almost 100 percent and production of seed in this region is seriously threatened. Although less susceptible, blue lupines are also attacked and they, too, may ultimately suffer serious damage.

Although virus diseases of grasses have not been studied so intensively, we are learning that some of the destructive virus diseases of cereals occur also in grasses. The effect on cereals is well known but the effect on grasses of economic importance is largely unknown.

FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE, BELTSVILLE, MARYLAND

NEMATODES AND GRASSLAND FARMING

By J. Lewis Allison

Plant parasitic nematodes play an important role in the failure to establish and maintain stands of many forage legumes in southern United States. Meadow nematodes, Pratylenchus spp., have been associated with the failure of spring-sown alfalfa and red clover in Kentucky and probably are one of several factors responsible for "clover-sick" soils in many regions. The clover cyst or clover root nematode, Heterodera trifolii, unreported in United States until 1938, has now been found in several States including North Carolina, and is known to damage seedling stands of Ladino and common white clover. The stem nematode, Ditylenchus sp., which attacks alfalfa, was thought to be confined to the inter-mountain regions of United States but has now been found causing serious damage to alfalfa in several locations in Virginia and in at least one location in North Carolina. Root-knot nematodes, Meloidogyne spp., occur throughout southern United States and although known to attack many forage legumes have until recently been considered relatively unimportant on these hosts.

However, in studies at North Carolina it was found that alfalfa; Ladino and common white, red, and crimson clovers; Korean, Kobe, and Sericea lespedezas; big and birdsfoot trefoils were all susceptible to attack by four root-knot nematode species, namely Meloidogyne arenaria, M. hapla, M. javanica, and M. incognita, and one subspecies, M. incognita acrita. Differences

in degree of susceptibility were found. Ladino clover was the most susceptible and none of the legumes were highly resistant. Lespedeza and Lotus spp. showed the greatest differences in reaction, indicating that selection and breeding for root-knot resistance is possible in these genera. The other legumes were more uniform in their reaction indicating that source material for improvement purposes may be limited.

Relatively little research has been done regarding the effect of parasitic nematodes on pasture grasses. However, the work to date indicates that certain nematode species multiply and in some instances cause damage to grass sods.

The nematode problems in grassland farming in southern United States are real and the combined efforts of plant pathologists, agronomists and plant breeders are needed to cope successfully with them.

FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE AND NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION, RALEIGH, NORTH CAROLINA

BREEDING FOR DISEASE RESISTANCE IN GRASSLAND CROPS

By Glen W. Burton

Plant diseases exact a heavy toll from grassland crops. They affect both the quantity and quality of forage produced and often become so severe as to prevent the growing of certain forage crops within a region. Effective disease control can, therefore, be expected to increase TDN production and also add stability and permanence to grassland agriculture by minimizing the seasonal hazards due to disease. The low per-acre value of many grassland crops and the need for control measures over long periods of time, particularly in the South, make the use of existing fungicides to control forage crop diseases prohibitive in most instances. Consequently, breeding for disease resistance, sometimes referred to as the "painless method", becomes, because of its low cost and widespread effectiveness, the "principal method" for the control of disease in grassland crops.

It is now generally agreed that the pathogens causing plant disease are composed of a complex group of biotypes or races capable of change. Thus, the genetic make-up of the parasite and the host must be considered throughout the breeding program. Not only must each segregating plant population be uniformly exposed to a maximum epidemic of the disease, but care must be taken to insure that the inoculum used includes (if possible) all biotypes to which the new variety will be subject on the farm. Even then, new parasitic biotypes may soon arise and make the once-resistant variety susceptible and obsolete. Artificial inoculation, a necessary procedure for effective advance in many situations, calls for team work between the pathologist and the plant breeder.

Obviously, sources of resistance in existing varieties or introductions (often wild types or related species) must be found. Complete immunity is highly desirable because, in addition to giving complete control, it facilitates screening and prevents the parasite from developing new biotypes of greater pathogenicity to the host. The various methods that may be used in breeding for disease resistance include mass selection, recurrent selection, recurrent-reciprocal selection, backcrossing, inbreeding, and intro- and inter-specific hybridization.

FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE AND UNIVERSITY OF GEORGIA COASTAL PLAIN EXPERIMENT STATION, TIFTON, GEORGIA

VIGNA AND CROTALARIA VIRUSES IN FLORIDA[1]

C. W. Anderson

Abstract

I. Preliminary report on a strain of cucumber mosaic virus from cowpea plants. II. Notations concerning cowpea mosaic virus (Marmor vignae). III. Notations concerning identification difficulties, indicator plants, possible vector relationships, and virus maintenance.

Mosaic disease apparently spread from two cowpea fields to plants of Crotalaria, Desmodium, and Cassia. Tobacco etch virus was obtained from Cassia plants, as indicated in a previous report. Two other viruses obtained from the fields are described below.

An apparently undescribed strain of cucumber mosaic virus (Marmor cucumeris) was obtained from plants of cowpea, lima bean, and Solanum gracile. For convenience only, the virus was considered a substrain of Harter's lima bean mosaic strain. The virus infected 15 plant species, including 7 legumes. It withstood 6 hours aging and about 1:100 dilution. It protected plants of Zinnia elegans against Marmor cucumeris judicis.

Blackeye cowpea mosaic virus was obtained from plants of cowpea, Crotalaria, and Desmodium. The virus was considered a strain of Marmor vignae. The strain withstood 60° C./10 min.; 1 day's aging; and 1:10,000 dilution. It caused systemic infection in plants of the genera Vigna, Phaseolus, Vicia, Crotalaria, Canavalia, and Desmodium. Local symptomless infection occurred in the non-leguminous genera Zinnia and Chenopodium. Preliminary studies suggested that the virus may be aphid-transmissible and seedborne.

The various Vigna and Crotalaria viruses were classified into seven groups. A list of plants which should prove useful indicators for these sap-transmissible viruses was compiled from the literature. Methods of maintaining Vigna viruses with a minimum amount of contamination from seedborne viruses were discussed.

Evidently, the nonpersistent aphid-borne viruses are rarely transmitted by chewing insects also. The nonpersistent aphid-borne viruses are largely or entirely inactivated by about 15 days' aging in most cases. On the other hand, viruses transmitted by chewing insects often withstand aging for 20 days or even longer.

[1] The writer is indebted to E. West, who determined the plant species used and checked the botanical nomenclature; to A. N. Tissot, who determined the five aphid species used; and to A. P. Lorz, who discussed the unstandardized varietal nomenclature and the extensive genetic variability of Vigna.

VIGNA AND CROTALARIA VIRUSES IN FLORIDA
I. PRELIMINARY REPORT ON A STRAIN OF CUCUMBER MOSAIC VIRUS OBTAINED FROM COWPEA PLANTS[1]

C. W. Anderson

In May 1953, mosaic disease was found on plants of cowpea (Vigna sinensis (Torner) Savi), lima bean (Phaseolus limensis MacF.), and pepper (Capsicum frutescens L.) in a field at Gainesville, Florida. Mosaic disease was also found in a cowpea field. The disease appeared to spread from plants in the first field to plants of Crotalaria spectabilis Roth., Desmodium tortuosum (Sw.) DC., and Cassia tora L. This report concerns a strain of cucumber mosaic virus obtained from cowpea plants in both fields and from lima bean. A second mosaic virus was obtained from some of the cowpea plants and from Crotalaria and Desmodium plants. Tobacco etch virus (1) was obtained from the Cassia plants. No study was made of the virus causing pepper mosaic in the first field.

MATERIALS AND METHODS

Viruses used were: cowpea isolate of Marmor cucumeris Holmes; M. cucumeris judicis Holmes supplied by S. P. Doolittle; and M. medicaginis Holmes supplied by H. H. McKinney. The carborundum method of mechanical inoculation was used. The two fields were observed at intervals through June, 1954. Attempts were made to transmit virus from apparently diseased plants of several species to plants of cowpea and either pepper or Nicotiana glutinosa L.

RESULTS

Isolations from field plants: The cucumber mosaic virus strain was obtained from plants of cowpea, lima bean, and Solanum gracile Link. No virus was obtained from apparently diseased plants of the genera Medicago, Melilotus, Geranium, Ambrosia, Boerhavia, Galacta, Oenothera, Campsis, Erechtites, Glycine, Erigeron, and Monarda; or from plants of Desmodium incanum DC. Glycine, Erigeron, Monarda, and Desmodium incanum may well have been been affected by non-virus troubles. Mosaic also occurred on plants of the genera Phytolacca, Bidens, Chenopodium, and Sida in the area. These diseases probably were not caused by the cucumber mosaic virus strain.

Hosts and Symptoms: The following plants proved susceptible to the cucumber mosaic virus strain: Vigna sinensis, Henderson Bush and Fordhook lima bean (Phaseolus limensis), P. vulgaris L. (bean), Pisum sativum L. (pea), Dolichos lablab L., Crotalaria mucronata Desv., Vicia faba L. (broadbean), Nicotiana tabacum L. (tobacco), N. glutinosa, Lycopersicon esculentum Mill. (tomato), Capsicum frutescens (California wonder and Tabasco peppers), Cucumis sativus L. (cucumber), Zinnia elegans Jacq. (zinnia), Lactuca sativa L.(lettuce), and Apium graveolens L. (celery). The virus was recovered (repeatedly in most cases) from plants of each species. Very few inoculated plants of Fordhook lima bean, Crotalaria mucronata, tomato, cucumber, or celery developed systemic symptoms.

Fordhook lima bean plants developed large, reddish, irregular necrotic ring lesions followed occasionally by systemic mottle, stunting, and distortion. Broadbean displayed local red necrotic ring lesions without systemic infection. California wonder pepper plants developed local chlorotic or whitish lesions (often in the form of concentric rings) and severe systemic mottle, distortion, and stunting; Tabasco pepper, local chlorotic or necrotic ring and oakleaf patterns followed by similar systemic patterns and mottle, distortion, leaf drop, and stunt. Essentially, the symptoms developed by plants of Henderson Bush lima bean, Dolichos, Crotalaria, Nicotiana glutinosa, tomato, zinnia, and celery consisted of systemic mottle, distortion, and stunting. Most of these plants developed only mild to moderate symptoms. However, Crotalaria plants displayed severe symptoms and celery displayed some necrosis. Pea, tobacco, and cucumber plants were essentially symptomless carriers. Tobacco plants were easily infected, and the virus was readily recovered from them. However, transient vein clearing and very mild transient mottle were the strongest symptoms these plants displayed. Likewise, pea developed transient veinclearing. The virus was easily transmitted to and recovered from pea plants. Some cucumber plants developed faint, small chlorotic spots on the veins of

[1] Florida Agricultural Experiment Station Journal Series, No. 383. (For Abstract and Acknowledgment, see above, page 345).

noninoculated leaves. The virus was sometimes recovered from these leaves, and was recovered more often from the symptomless inoculated leaves. Lettuce plants never displayed symptoms and virus was never recovered from noninoculated lettuce leaves. However, the virus was readily recovered from inoculated lettuce leaves.

Plants of Glycine max (L.) Merr. (soybean), Cassia tora, Desmodium incanum, Canavalia ensiformis (L.) DC., C. gladiata (Jacq.) DC., Crotalaria spectabilis, Ambrosia artemisiifolia L. (ragweed), Bidens pilosa L., and Commelina nudiflora L. were evidently immune, and no virus was recovered from them. However, only limited tests were made with plants of the last five species.

Reactions of Cowpea Plants: Plants of Alabama Crowder, Conch, Dixie Queen, and Blackeye cowpea (two strains), Black hog pea, and the cowpea strain reported by Sill and Walker (7) developed local and systemic symptoms. Local lesions in Sill and Walker's cowpea strain consisted of poorly-defined chlorotic areas. The other varieties showed poorly-defined reddish necrotic rings, lines, and markings in addition to the chlorotic areas. Systemic symptoms in all except one variety consisted almost entirely of mild mottle, stunt, and distortion. Early Wilt-Resistant Ramshorn Blackeye cowpea alone developed severe mottle and distortion and considerable reddish vein necrosis. Unfortunately, this variety was not included in the parallel inoculations. It was used extensively in the earlier experiments and was replaced by the second Blackeye strain later.

Symptoms in most varieties were mild, or partly masked, under some conditions. This fact led to the theory that the virus may be overlooked in the field. Field observations and isolations from field plants confirmed this theory.

Physical Properties: In sap of infected Blackeye cowpea plants, the virus withstood 6 but not 24 hours' aging. Sap diluted 1:100 was usually infectious; that diluted 1:1,000 or higher was almost always non-infectious. Similarly, the virus rarely withstood more than 1:100 dilution in infectious Nicotiana glutinosa sap. However, it withstood 1:1,000 dilution in sap of California Wonder pepper fairly readily. In all cases, the test plants were of the same type as that from which the infectious sap was obtained.

Immunological Studies: The virus failed to protect Nicotiana glutinosa plants from either local or systemic invasion by Marmor medicaginis. The virus did protect zinnia plants from the local lesions of M. cucumeris judicis. Therefore, the virus appears to be related to cucumber mosaic virus.

DISCUSSION AND CONCLUSIONS

Virus Identity: The host range, symptoms, and immunological reactions of this virus indicate that it is a strain of cucumber mosaic virus, despite the fact that it proved unusually nonresistant to dilution and aging for a strain of this virus. The cowpea virus therefore differs from all viruses previously obtained from cowpea plants. The virus differs from most reported strains of cucumber mosaic virus in causing systemic disease in cowpea plants and in remaining essentially latent in plants of cucumber and tobacco. Some strains cause systemic disease on cowpea plants (2, 3, 5, 6, 8), and one attacks lima bean plants in the field (4). All these strains (strains A, B, C, and F of Fulton; 14 of Whipple and Walker; pepper ringspot of Doolittle and Zaumeyer; Y or 9 of Price; and Harter's lima bean mosaic strain) cause more severe symptoms in tobacco than does the cowpea virus. All except perhaps strain 9 (Y), whose symptoms were unreported, cause more severe systemic symptoms on cucumber; and most cause local lesions on it. Of the strains considered, Harter's lima bean strain was the only one that caused only local symptoms on cowpea plants. The reactions of plants of pepper, pea, zinnia, and broadbean differentiate some of the strains from the cowpea virus. Therefore, the cowpea strain is evidently undescribed. For convenience only, it may be considered together with Harter's strain, as Marmor cucumeris phaseoli Holmes.

Indicator Plants and Recommended Methods: The virus was recovered on California Wonder pepper plants for two reasons. The plants were readily infected, provided that four young leaves on each plant were inoculated. Moreover, the plants displayed more definite and distinctive symptoms than did most of the other hosts. Cowpea plants were also readily infected, especially if the inoculated leaves were not fully expanded. These plants provided better inoculum than most other species that consistently developed disease symptoms. This explains why the virus

was also recovered on cowpea plants, and why cowpea inoculum was normally used.

Plants of pepper, zinnia, broadbean, and Dolichos were susceptible to this virus, while those of Cassia, Canavalia ensiformis, and Desmodium incanum were immune. The reactions of these plants differentiate this virus from certain other viruses reportedly attacking cowpea plants in the field.

Virus Sources and Importance: The cowpea virus caused mild symptoms in several hosts and was essentially latent in others. It was obtained from plants of cowpea and of Solanum gracile that showed only slight evidence of disease in the field. S. gracile may or may not prove an important virus source. Various other plants may prove sources of this virus in the field, whether or not they display obvious disease symptoms.

The virus was obtained from unidentified cowpea strains showing severe disease in the field, as well as from strains displaying mild symptoms. It caused severe disease symptoms on Early Wilt-Resistant Ramshorn Blackeye plants in the greenhouse, although milder symptoms appeared on other varieties tested. The virus was obtained from severely diseased lima bean plants in the field and caused decided symptoms on lima bean in the greenhouse. Therefore, the virus is potentially important to growers of lima bean and of some cowpea varieties. Moreover, the virus may cause yield reduction in cowpea varieties showing mild symptoms. Finally, this virus and other viruses may infect the same plants, causing exceptionally severe disease.

SUMMARY

A virus obtained from plants of cowpea, lima bean, and Solanum gracile was identified as a strain of cucumber mosaic virus. The virus infected plants of 15 species, including 7 legumes. It tolerated 6 hours aging and about 1:100 dilution. Plants of cowpea, pepper, tobacco, zinnia, broadbean, Dolichos lablab, Canavalia ensiformis, Desmodium incanum, and Cassia tora are useful in distinguishing this virus from others. The last three species were immune. Methods of identifying this virus, its sources, and its importance are discussed.

Literature Cited

1. Anderson, C. W. 1954. Cassia tora, a leguminous host of tobacco etch virus. Plant Dis. Reptr. 38: 736-738.
2. Doolittle, S. P., and W. J. Zaumeyer. 1953. A pepper ringspot caused by strains of cucumber mosaic virus from pepper and alfalfa. Phytopath. 43: 333-337.
3. Fulton, J. P. 1950. Studies on strains of cucumber virus 1 from spinach. Phytopath. 40: 729-736.
4. Harter, L. L. 1938. Mosaic of lima beans (Phaseolus lunatus macrocarpus). Jour. Agr. Res. (U. S.) 56: 895-906.
5. Price, W. C. 1934. Isolation and study of some yellow strains of cucumber mosaic virus. Phytopath. 24: 743-761.
6. _____. 1935. Acquired immunity from cucumber mosaic in zinnia. Phytopath. 25: 776-789.
7. Sill, W. H. Jr., and J. C. Walker. 1952. A strain of cowpea susceptible to systemic infection by various strains of common cucumber mosaic virus. Phytopath. 42: 442.
8. Whipple, O. C., and J. C. Walker, 1941. Strains of cucumber mosaic virus pathogenic on bean and pea. Jour. Agr. Res. (U. S.) 62: 27-60.

FLORIDA AGRICULTURAL EXPERIMENT STATION, GAINESVILLE

VIGNA AND CROTALARIA VIRUSES IN FLORIDA
II. NOTATIONS CONCERNING COWPEA MOSAIC VIRUS (MARMOR VIGNAE)[1]

C. W. Anderson

The preceding report (1) described a strain of cucumber mosaic virus obtained from cowpea plants in two fields, and noted that two other viruses were obtained from these fields. This report concerns the second virus obtained from cowpea plants in the fields. The third virus was obtained only from plants other than cowpea and did not infect cowpea plants in the greenhouse.

MATERIALS AND METHODS

Several virus isolates obtained from plants of cowpea and of two other species in fields 1 or 2 (1) appeared identical. One isolate--obtained from Crotalaria spectabilis in field 2--was selected for further study. The carborundum method of mechanical inoculation was used.

RESULTS

Isolations from Field Plants: Mosaic disease was first noted on plants of cowpea and lima bean in field 1 and on cowpea plants in field 2 (1). Many plants had apparently become infected while very young. Later, mosaic was observed on plants of Crotalaria spectabilis growing in or near both fields and on plants of Desmodium tortuosum at field 1. The Crotalaria and Desmodium plants were large and displayed mosaic symptoms only on their younger leaves. Apparently, mosaic disease had spread from plants of cowpea to Crotalaria and Desmodium. An apparently identical virus was obtained from all three species, but this virus was not secured from other neighboring plants (1) from which isolations were made.

Hosts and Symptoms: The following plants proved susceptible to the virus: cowpea, Henderson Bush and Fordhook lima beans, broadbean, Desmodium incanum, Crotalaria spectabilis, C. mucronata, Canavalia ensiformis, C. gladiata, soybean, Dolichos lablab, Cassia tora, zinnia, and Chenopodium ambrosioides anthelminthicum (L.) A. Gray. Systemic infection developed only in plants of cowpea, two lima bean varieties, broadbean, Desmodium, Crotalaria spectabilis, and Canavalia ensiformis. The virus was recovered from non-inoculated parts of plants of each of these types. Only local infection occurred in the remaining plant types, and definite local symptoms were noted on only three of these: Canavalia gladiata, Dolichos, and Cassia. The virus was recovered from only the inoculated leaves of each plant type in which only local infection developed, with one exception. The virus was not recovered from Cassia plants. Only two inoculated broadbean plants became systemically infected.

Symptoms induced by this virus were as follows: severe mottle, distortion, stunting, leaf dropping, and some necrosis (Desmodium incanum); severe mottle with some distortion and stunting (broadbean); mottle consisting largely of broad green areas along the veins and interveinal chlorosis (Crotalaria spectabilis); chlorotic local lesions with necrotic borders plus systemic mottle, distortion, stunting, and reddish vein necrosis (Henderson bush lima bean); mild mottle (Fordhook lima bean); crinkling of young inoculated leaves and extremely mild systemic mottle (Canavalia ensiformis); crinkling of young inoculated leaves (C. gladiata); local lesions consisting of mildly chlorotic spots, light reddish rings, or both (Dolichos); and solid bluish-black local lesions which tended to spread along the veins, plus chlorosis of inoculated leaves (Cassia).

Plants of pea, bean, tobacco, Nicotiana glutinosa, California Wonder pepper, tomato, cucumber, lettuce, ragweed, Bidens pilosa, celery, Phytolacca rigida Small, Sida sp., and Commelina nudiflora were evidently immune. However, recovery of virus was not attempted from pepper plants. Only limited inoculations were made with plants of ragweed, Bidens, Phytolacca, Sida, and Commelina.

Varietal Susceptibility of Cowpea Plants: The virus caused local and systemic symptoms on plants of two Blackeye cowpea strains and on Alabama Crowder, Conch, and Dixie Queen

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cowpea and Black hog pea. No definite symptoms were induced on plants of the strain of cowpea of Sill and Walker (12). Plants of the Blackeye varieties invariably developed rather large, reddish, and often ringlike local lesions which often spread along the veins, forming a "reddish-net" pattern. All inoculated Blackeye plants became infected, regardless of the age of the inoculated simple leaf tissue or of environmental conditions, provided that undiluted sap inoculum from the Blackeye cowpea varieties was used.

Systemic symptoms on Blackeye plants consisted of severe mottle, stunting, distortion, and some reddish vein necrosis. On Early Wilt-Resistant Ramshorn Blackeye, symptoms included mottle in which green bands along the veins commonly alternated with chlorotic or whitish interveinal areas, together with some stunting and distortion. Unfortunately, this variety was not included in the parallel inoculations. Ramshorn Blackeye plants were used extensively in the earlier tests and were replaced by Blackeye plants later. Local lesions in plants of the other varieties tended to be smaller and solid rather than ring-like. Systemic symptoms usually consisted either of a relatively fine mottle or of secondary reddish necrotic lesions with or without reddish vein necrosis. Black hog pea, from which the virus was not recovered, displayed systemic symptoms of only the necrotic type. Whether or not Sill and Walker's cowpea strain is immune to this virus cannot be stated, but the strain is certainly highly resistant.

Recovery of Virus from Various Plants: Local lesions induced on cowpea plants of the Blackeye varieties following inoculation with undiluted sap of various infected species varied from 1 to about 294 per plant. The lesions required about 6 to 19 days to develop in winter, and about 4 to 8 days in summer, depending upon whether or not undiluted inoculum was used, and other factors. Systemic symptoms commonly appeared within 9 to 20 days in winter, and within 6 to 10 days in summer, in the Blackeye plants. Environmental factors, age of the inoculated simple leaves, and other matters undoubtedly influenced the results. However, examination of the detailed experimental records indicates that the source of inoculum was among the most important factors determining the number of lesions induced by undiluted inoculum. Sap from infected parts of Chenopodium and Dolichos plants consistently produced only a few lesions on cowpea. Sap from infected Cassia and Black hog pea induced no lesions, despite the occurrence of local symptoms in Cassia and of local and systemic symptoms in Black hog pea plants. Desmodium sap (which caused some necrosis and curling on inoculated cowpea leaves from an apparent toxic reaction) sometimes induced only a few virus lesions. Incidentally, even the occurrence of only one lesion on the Blackeye cowpeas was invariably followed by systemic symptoms; while plants not showing lesions never developed systemic infection.

Physical Properties: In experiments using Blackeye cowpea source and test plants, the virus withstood 60° but not 65° C./10 min.; 1:10,000 but not 1:50,000 dilution; and 1 but not 2 days aging at 18° to 21° C.

Insect and Seed Transmission: In preliminary tests, single insects of Macrosiphum solanifolii (Ashmead) transmitted the virus twice and Aphis gossypii Glover transmitted it once. Similarly, one seedling grown from seed collected from mosaic plants in the field was infected. Although these tests are inconclusive no virus appeared in the control plants.

DISCUSSION AND CONCLUSIONS

Virus Identity: There seems no reason to compare this virus in detail with viruses other than those obtained from Vigna or Crotalaria. The previously reported viruses of Vigna and Crotalaria cannot be classified with certainty at present. However, the viruses were tentatively assigned to seven groups. One group (Marmor vignae Holmes) was subdivided into four subgroups. The present virus belongs in Subgroup C of Group 2 (M. vignae). The name Blackeye cowpea mosaic virus is suggested as the common name of the viruses of this subgroup.

The groups are characterized below.

Group 1. Cucumber Mosaic (Marmor cucumeris Holmes) Virus Strain. This virus (1) displays an immunolgical relationship to M. cucumeris in zinnia. It infects several non-leguminous plants. Presumably, its physical properties and vectors resemble those of the type virus. However, the strain was unusually nonresistant to aging and to dilution.

Group 2. Cowpea Mosaic Virus (Marmor vignae Holmes). Holmes (7) listed the viruses of Smith (13) and McLean (9) under this name. Dale (5) is probably

correct in stating that Smith's inadequately described virus is unrelated to that of McLean. In this report, McLean's virus is considered the type strain. Four presumed subgroups of this virus are listed below. The viruses of this group withstand not more than 3 days aging or 1:10,000 dilution. Only certain leguminous plants become systemically infected. Most (and conceivably all) of these viruses are transmitted by aphids and by seed.

Subgroup A. Cowpea Mosaic Virus McLean. McLean's virus (9) is aphid-transmissible and seedborne. Its thermal inactivation point lay between 72° and 75° C./10 minutes.

Subgroup B. Cowpea Mosaic Viruses 2 and 3 Oliveira. These two viruses (8) withstood about 70° C/10 minutes. They caused only systemic symptoms in Vigna varieties and did not infect Black cowpea plants. They were not seedborne.

Subgroup C. Blackeye Cowpea Mosaic Virus. Yu's seedborne virus (17), Oliveira's cowpea mosaic virus 1 (8), and the present are placed in this group. These viruses withstood about 60° C./10 minutes and caused local and systemic symptoms in Vigna varieties. Oliveira obtained no evidence of seed transmission.

Subgroup D. Asparagus Bean Mosaic Virus Snyder. The thermal inactivation point of Snyder's virus (14) lay between 55° and 60° C./10 minutes. Snyder did not state that his virus caused local lesions in Vigna varieties. The virus was transmitted by aphids and by seed. Unlike the viruses of Groups 2A to 2C, this virus sometimes caused systemic symptoms in bean plants.

Group 3. Cowpea Mosaic Virus Dale. This virus (5) was transmitted by beetles (Ceratoma spp.) and by seed, but not by aphids. It withstood 20 days aging and 1:100,000 dilution. Its thermal inactivation point lay between 65° and 66° C./10 minutes. Its known host range is restricted to the legume family. Like some viruses of Group 2, it caused local and systemic symptoms in cowpea varieties. Following Dale's suggestion, Smith's virus (13) is included in this group.

Group 4. Catjang Mosaic Virus Capoor et al. This virus (4) is distinguished by its thermal inactivation point (between 85° and 90° C.) and by its resistance to aging (between 9 and 15 days). It resembled most viruses of Groups 2 and 3 in being transmissible by seed. Like most viruses of Group 2, it was transmitted by aphids. The virus infected certain leguminous plants only.

Group 5. Thermostable Cowpea Mosaic Viruses. Warid and Plakidas (15, 16) partially described three viruses which withstood 98° C. or higher for at least 10 minutes. At least one virus was seedborne in bean. Apparently, some or all of the viruses infected certain non-leguminous plants.

Group 6. Sunn Hemp Mosaic Virus Raychaudhuri. This Crotalaria virus (10) did not infect cowpea plants. Little is known about its host range and methods of transmission. Its thermal inactivation point lay between 68° and 70° C./10 minutes. It resisted 71 but not 76 days aging. The virus is almost certainly distinct from those of Groups 1 to 5.

Group 7. Crotalaria mucronata Mosaic Virus Raychaudhuri et al. This virus (11) and southern sunn hemp mosaic virus (3), which was described slightly earlier, are placed together in Group 7. The two viruses withstood 80° to 90° C./10 minutes; 134 days aging or longer; and at least 1:20,000 dilution. One virus caused local lesions on pepper and Nicotiana glutinosa plants; the other was not tested on these species. The two viruses are clearly distinct from those of Groups 1 to 5. Conceivably, the viruses of Groups 6 and 7 are related.

Other viruses attacking Vigna or Crotalaria plants have been mentioned. Only partial descriptions of some of these were presented, and descriptions of others were not available. However, Brooks (2) and Gates (6) reported mosaic of Crotalaria spectabilis from Florida, and Brooks mentioned mosaic of cowpea. The symptoms shown by Gates do not appear identical with those of Blackeye cowpea mosaic virus. Brooks lent the writer photographs of the diseases with which he worked. Varietal differences in cowpea plant reactions to the Blackeye cowpea mosaic virus prevented any conclusions from being drawn. However, the fine Crotalaria photographs displayed a disease apparently identical with that caused in both field and laboratory by Blackeye cowpea mosaic virus.

The writer believes that binomials should be selected for the viruses of Groups 3, 4, and 7. At least one binomial will be needed for the viruses of Group 5 when additional information becomes available.

Sources, Importance, and Possible Control: McLean (9), Yu (17), and Snyder (14) obtained evidence that viruses herein considered strains of Marmor vignae are seedborne. These workers and Oliveira (8) obtained viruses of this group only from Vigna species. Blackeye cowpea mosaic virus was obtained from annual plants of Crotalaria and Desmodium as well as from Vigna in this study. For reasons explained above, Crotalaria and Desmodium were considered secondary hosts. Neither showed evidence of virus disease in seedlings sprouting the following year in the same fields. However, Crotalaria seeds no not necessarily sprout the year following their production. One must conclude that Vigna seed is the only proved source of the M. vignae strains. McLean (9) found that the virus was more readily seedborne in some cowpea varieties than in others. Possibly, the virus strain also affects the amount of seed transmission obtained. Moreover, certain unreported results obtained in this study suggest the possibility that seedborne virus may be readily detected only in certain varieties.

The importance of Marmor vignae in Florida is undetermined. However, present evidence suggests that many cowpea fields do not manifest obvious disease symptoms. Control methods are also inadequately known. However, it may prove possible to control this virus by means of resistant varieties, or perhaps by producing disease-free seed. The latter, of course, would be simplest in those varieties which do manifest obvious disease symptoms.

SUMMARY

Blackeye cowpea mosaic virus attacked plants of cowpea, Crotalaria, and Desmodium in the field. In the laboratory, it caused systemic infection in plants of the genera Vigna, Phaseolus, Vicia, Crotalaria, Canavalia, and Desmodium; local infection in Glycine, Dolichos, and Cassia; and local infection in the non-leguminous genera Zinnia and Chenopodium. It withstood 60° C./10 minutes; 1:10,000 dilution; and 1 day's aging. Preliminary studies suggested that it may prove aphid-transmissible and seedborne.

Viruses described from Vigna or Crotalaria were tentatively separated into seven groups. Blackeye cowpea mosaic virus was tentatively considered a strain of Marmor vignae (with McLean's virus as the type strain). The members of the Blackeye cowpea mosaic virus subgroup are probably sufficiently different from the type to consitute a distinct variety.

The sources, importance, and possible control methods for blackeye cowpea mosaic virus were briefly discussed.

Literature Cited

1. Anderson, C. W. 1955. Vigna and Crotalaria viruses in Florida. I. Preliminary report on a strain of cucumber mosaic virus obtained from cowpea plants. Plant Dis. Reptr. 39: 346-348.
2. Brooks, A. N. 1937; 1938. Virous diseases of tomato and pepper; Virous diseases of pepper and tomato. Florida Agr. Exp. Sta. Ann. Rept., 1936: 94-96; 1937: 104-105.
3. Capoor, S. P. 1950. A mosaic disease of sunn hemp in Bombay. Curr. Sci. 19: 22.
4. _____, P. M. Varma, and B. N. Uppal. 1947. A mosaic disease of Vigna catjang Walp. Curr. Sci. 16: 151.
5. Dale, W. T. 1949. Observations on a virus disease of cowpea in Trinidad. Ann. Appl. Biol. 36: 327-333.
6. Gates, C. M. 1950. A mosaic and little leaf disease of Crotalaria spectabilis in south Florida. Plant Dis. Reptr. 34: 203-204.
7. Holmes, F. O. 1948. Order Virales. The filterable viruses. Bergey's Manual of Determinative Bacteriology, ed. 6, suppl. 2: 1127-1286. Williams & Wilkins Co., Baltimore, Md.
8. Oliveira, M. A. de. 1947. Contribuicao ao estudo dos virus causadores de mosaico nos feijoes macassar (Vigna spp.). Bol. Tecn. Agron. Sul (Pelotas) 1: 1-36.
9. McLean, D. M. 1941. Studies on a mosaic of cowpea, Vigna sinensis. Phytopath. 31: 420-430.

10. Raychaudhuri, S. P. 1947. A note on a mosaic virus of sann-hemp Crotalaria juncea Linn.) and its crystallization. Curr. Sci. 16: 26-28.
11. _____, and P. S. Parthanian. 1950. A mosaic disease of Crotalaria mucronata Desv. (C. striata DC.). Curr. Sci. 19: 213.
12. Sill, W. H. Jr., and J. C. Walker. 1952. A strain of cowpea susceptible to systemic infection by various strains of common cucumber mosaic virus. Phytopath. 42: 442.
13. Smith, C. E. 1924. Transmission of cowpea mosaic by the bean leaf-beetle. Science 60: 268.
14. Snyder, W. C. 1942. A seed-borne mosaic of asparagus bean, Vigna sesquipedalis. Phytopath. 32: 518-523.
15. Warid, W. A., and A. G. Plakidas. 1950. New viruses naturally infectious to cowpea. Phytopath. 40: 30-31.
16. _____, and _____. 1952. Thermophilic viruses naturally infectious to cowpea. Plant Dis. Reptr. 36: 380-381.
17. Yu, T. F. 1946. A mosaic disease of cowpea (Vigna sinensis Endl.). Ann. Appl. Biol. 33: 450-454.

FLORIDA AGRICULTURAL EXPERIMENT STATION, GAINESVILLE

VIGNA AND CROTALARIA VIRUSES IN FLORIDA III. NOTATIONS CONCERNING IDENTIFICATION DIFFICULTIES, INDICATOR PLANTS, POSSIBLE VECTOR RELATIONSHIPS, AND VIRUS MAINTENANCE[1]

C. W. Anderson

IDENTIFICATION DIFFICULTIES

Several of the recently classified (2) Vigna-Crotalaria viruses were reportedly seedborne in cowpea or bean. The viruses of Groups 2, 3, 4, and 6 caused symptoms only on plants of certain members of 13 leguminous genera: Cajanus, Canavalia, Cassia, Crotalaria, Desmodium, Dolichos, Glycine, Phaseolus, Pisum, Psophocarpus, Sesbania, Vicia, and Vigna. Most of the viruses considered were tested on relatively few species of the 13 genera. Often, different workers inoculated different varieties of the same species. In several cases, given viruses reacted differently on plants of different varieties of a single species. Immunological and/or serological studies were generally lacking. Consequently, the classification scheme was tentative.

In future studies, more of the indicator plants listed below should be inoculated with each virus. Standarized plant varieties should be inoculated with each virus. Studies of insect transmission, immunology, and serology should be made with each virus discovered. Finally, the viruses should be maintained in ways which will reduce the possible occurrence of seedborne contaminant viruses.

INDICATOR PLANTS

The viruses of Groups 1 and 7 caused specific, distinctive reactions on plants of pepper and Nicotiana glutinosa (Table 1). However, only one of the two viruses of Group 7 was inoculated into plants of these species.

All tested isolates of Group 2 (Marmor vignae Holmes) were relatively nonresistant to aging and to dilution and were aphid-transmissible. Several of the isolates were seedborne, but Oliveira's viruses (Groups 2B and 2C) were not. Three isolates (Groups 2A and 2B) withstood 70° C. or higher. Snyder's virus (Group 2D) was inactivated by 60° C. Some Group 2 isolates infected plants of certain varieties of Vigna, bean, or pea. Others failed to infect certain varieties of these species. Similarly, certain isolates caused symptoms on plants of broadbean, Dolichos lablab, Canavalia ensiformis, or Crotalaria spectabilis. Others failed to infect these plants. The many differences suggest that unrelated viruses may have been included even within individual subgroups of Group 2. However, differences in virus stains or in the reactions of plant varieties might explain all the variations noted. All Group 2 viruses caused mosaic on plants of some varieties of Vigna and lima bean. None readily induced mosaic symptoms on bean or broadbean plants. None caused symptoms of systemic infection on plants of the leguminous genera Arachis, Cicer, Glycine, Lathyrus, Lens, Lespedeza, Lupinus, Medicago, Melilotus, or Trifolium; or on plants of any non-leguminous species.

Unlike the Group 2 viruses, Dale's cowpea mosaic virus (Group 3) caused mosaic on soybean plants. Moreover, Dale's virus caused only local lesions on Canavalia ensiformis plants. Neither of the two tested Group 2 isolates duplicated this reaction.

The viruses of Group 4 (catjang mosaic) and 6 (sunn hemp mosaic) were tested on relatively few plants susceptible to the viruses of the other groups (Table 1). Catjang mosaic virus caused mosaic on Canavalia ensiformis plants and therefore differed from the viruses of Groups 1 and 3. Whether or not its host reactions differed greatly from those of the viruses of Groups 2 and 6 is undetermined. Sunn hemp mosaic virus alone failed to infect Vigna plants. The utility of this difference will not become apparent until all the viruses have been tested on several identical Vigna varieties.

The Group 5 viruses were not included in Table 1. Warid and Plakidas (12) implied that some or all their viruses caused symptoms on various non-leguminous plants. Of the other viruses, only those of Groups 1 and 7 induced disease on non-legumes. Unfortunately, the reactions produced by specific Group 5 viruses were not listed.

Plants not listed in Table 1 but susceptible to certain Vigna-Crotalaria viruses other than

[1] Florida Agricultural Experiment Station Journal Series, No. 385. (For Abstract and Acknowledgment, see above, page 345).

Table 1. Reactions of 17 indicator plants to Vigna and Crotalaria viruses.

VIRUS GROUP[a]	1	2				3	4	6	7
VIRUS[b]	Cucumber mosaic strain	Cowpea mosaic Marmor vignae				Dale's cowpea mosaic	Catjang mosaic	Sunn hemp mosaic	Crotalaria mucronata mosaic
		A	B	C	D				
INDICATOR PLANTS[c]									
Vigna spp.	LS[d]	S	N-S	N-LS	N-S	LS	S	N	T-S
Phaseolus limensis	SL	N-S		SL		S, L?	S		S
P. vulgaris	S	N	N	N-L	S*	N			S
Pisum sativum	SS	N	N-S	N-S	N				
Glycine max	N		N	N-LT	N	S			
Vicia faba	L	N	N	N-S*					N
Cajanus cajan						S			N
Canavalia ensiformis	N			N-IS		L	S		
Cassia tora	N			L					
Crotalaria juncea						S		S	S
C. mucronata	S*			LT					S
C. spectabilis	N		N-S	S					S
Desmodium spp.[e]	N			S		S			
Dolichos lablab	S			N-L		L			N
Zinnia elegans	S	N	N	N-LT			N		
Capsicum frutescens	LS	N	N	N					L
Nicotiana glutinosa	S	N	N	N	N	N	N		L

[a] The virus groups were previously designated (2).

[b] The virus nomenclature was previously designated (2).

[c] Different varieties, subspecies, or (in the cases of Vigna and Desmodium), even species of the indicator plants were inoculated with the different viruses in many cases.

[d] The meanings of the symbols are as follows:

- (Ex.: N-S) = Or. Used when a given virus isolate caused different reactions on different forms of a given indicator plant, or when different isolates of a given virus group caused different reactions on a given indicator plant.
- * (Ex.: S*) = Indicator plant difficult to infect.
- S = Systemic symptoms only.
- SS = Systemic symptoms very mild (essentially latent).
- LS = Local lesions and systemic symptoms.
- SL = Systemic symptoms only on some varieties; local lesions and systemic symptoms on others.
- S, L? = Systemic symptoms; not clear whether or not local symptoms also occurred.
- IS = Local and mild systemic symptoms (essentially latent), but local symptoms not in the form of lesions.
- L = Local lesions without systemic infection.
- T = Latent systemic infection.
- LT = Local latent (symptomless) infection only.
- N = Immune.

[e] Desmodium incanum plants were immune to Group 1 virus; D. incanum and D. tortuosum plants were infected by Group 2C virus; D. frutescens was infected with Group 3 virus.

those of Groups 1 and 5 include species of Canavalia, Crotalaria, Lathyrus, Phaseolus, Psophocarpus, Sesbania, Datura, Nicotiana, and Chenopodium. Inoculations of the following plants with each Vigna or Crotalaria virus is recommended: Vigna spp. (Black, Blackeye, and Sill and Walker's cowpeas; Yardlong bean; and catjang); Great Northern and Black Valentine beans; Henderson Bush and Fordhook lima beans; Little Marvel, Alaska, Resistant Perfection, and Resistant Wisconsin early sweet peas; soybean; broadbean; Lathyrus odoratus L.; Cajanus cajan (L.) Millsp. (= C. indicus Spreng.); Canavalia ensiformis; Cassia tora; Crotalaria juncea L.; C. mucronata; C. spectabilis; Desmodium incanum; Dolichos lablab; Phaseolus mungo L.; Psophocarpus tetragonalobus DC.; Sesbania speciosa Taub. ex Engl.; Medicago sativa L.; either Trifolium incarnatum L. or T. repens L.; Zinnia elegans; Nicotiana tabacum; N. glutinosa; Capsicum frutescens; Datura stramonium L.; Cucumis sativus; Apium graveolens; and Chenopodium ambrosioides anthelminticum. No single isolate has been tested on all these plants. Excluding the Group 5 viruses, at least one isolate has infected each plant except Medicago sativa, Trifolium incarnatum, and Lathyrus odoratus. One Group 7 isolate infected L. sativus L. Many chances of discovering host range or symptom differences among the various isolates are therefore provided. A better understanding of the natural relationships of the isolates (and especially of the Group 2 isolates) should result.

POSSIBLE VECTOR RELATIONSHIPS

Most nonpersistent aphid-borne viruses are largely or entirely inactivated by 10 to 15 days aging. Few are known to be transmitted by insects other than aphids. Radish virus 1 (10) belongs to this group. One of its strains withstood more than 3 weeks aging.

Tobacco mosaic, potato X, squash mosaic, eggplant mosaic (5), Dale's cowpea mosaic (Group 3), tobacco ringspot, turnip yellow mosaic, and wild cucumber mosaic viruses were transmitted by chewing insects. Aphids failed to transmit all except tobacco mosaic viruses Reports concerning the ability of aphids to transmit this virus are conflicting. Hoggan (8) found that aphids were very inefficient vectors which did not acquire virus from all infected species.

Tobacco mosaic, potato X, and squash mosaic viruses withstood aging 30 days or longer. Eggplant and Dale's cowpea mosaic viruses withstood at least 20 days aging. One tobacco ringspot virus strain (4) remained active for about 15 days. Turnip yellow mosaic virus withstood 9 but not 10 days aging. No report concerning the longevity of wild cucumber mosaic virus was found.

Cucurbit ring mosaic virus was transmitted by beetles but not by aphids. The virus was renamed muskmelon mosaic virus (7). This suggests that the virus is related to Marmor melonis Rader et al. Strains of M. melonis remained active 10 to 21 days.

Early reports indicate that potato spindle tuber virus is anomalous. Aphids and chewing insects transmitted it. Aging quickly inactivated the virus. Recently, Bonde and Merriam (3) encountered difficulty in confirming the vectors of this virus. They did not report their results in detail. No recent study concerning the longevity of this virus was found.

Cucumber mosaic virus is typical of the nonpersistent aphid-borne group. Freitag (6) presented inconclusive results in an attempt to confirm the finding that cucumber beetles transmit this virus. He discovered three cucurbit viruses (7) which were transmitted by beetles but not by aphids. Cabbage mosaic was later proved a complex disease (11) caused by strains of turnip virus 1 and cauliflower mosaic virus. Evidently, aphids and chewing insects transmitted part or all of the complex (9). Both viruses belong to the nonpersistent aphid-borne group. Although the strains believed responsible for the original cabbage disease withstood less than 10 days aging, the type strain of cauliflower mosaic virus remained active 11 to 14 days.

Evidently, most viruses transmitted by chewing insects withstood at least 10 to 30 days aging. Their longevity is therefore greater than that of most nonpersistent aphid-borne viruses. Few viruses are transmitted by both chewing insects and by aphids. Several viruses with chewing vectors withstand greater dilution than nonpersistent aphid-borne viruses which infect the same plant species. The viruses of tobacco etch, potato Y, Hyoscyamus 3, watermelon mosaic, radish 1, and probably cowpea mosaic (Group 2) and catjang mosaic belong to the nonpersistent aphid-borne group. Each has hosts in common with certain of the viruses with chewing vectors.

Further study of the vectors and/or longevity of several viruses mentioned above and of the Vigna-Crotalaria viruses of Groups 5, 6, and 7 could provide added evidence concerning the validity of the above correlations. Variable fasting and feeding periods should be used in the vector studies. Vector tests with the Vigna viruses of Groups 1 (cucumber mosaic) and 2 (Blackeye cowpea mosaic) are planned at this laboratory.

VIRUS MAINTENANCE

Contaminating seedborne viruses could hamper the study of Vigna viruses. Maintaining isolates in frozen sap or dessicated tissue or maintaining healthy seedlots might reduce this difficulty. Maintaining isolates in plants in which seed transmission does not occur or which are immune to other seedborne viruses are possible solutions to the maintenance problem.

One can maintain Blackeye cowpea mosaic virus (Group 2) in Desmodium incanum plants. The plants are readily infected. They become so severely stunted that subinoculation or cutting back is seldom required. However, the plants may contain an inhibitor (2). Information about D. incanum viruses is limited. One abnormality (1) found in the field may not have been due to a virus. A second trouble, "ring mosaic", displayed symptoms typical of virus disease. Ring mosaic was not transmitted by sap or by seed in limited tests.

Most known hosts of the cucumber mosaic (Group 1) virus strain either developed inadequate symptoms, proved difficult to infect, were poor sources of inoculum, or grew rapidly and required considerable attention. A better method of maintaining this virus when not in use is desirable.

Literature Cited

1. Anderson, C. W. 1955. Vigna and Crotalaria viruses in Florida. I. Preliminary report on a strain of cucumber mosaic virus obtained from cowpea plants. Plant Dis. Reptr. 39: 346-348.
2. _____. 1955. Vigna and Crotalaria viruses in Florida. II. Notations concerning cowpea mosaic virus (Marmor vignae). Plant Dis. Reptr. 39: 349-353.
3. Bonde, R., and D. Merriam. 1951. Potato spindle tuber control. Maine Agr. Exp. Sta. (Orono) Bul. 487. 15 pp.
4. Cheo, P. C., and W. J. Zaumeyer. 1952. A new strain of tobacco ringspot virus isolated from bean. Plant Dis. Reptr. 36: 459-465.
5. Dale, W. T. 1954. Sap-transmissible mosaic diseases of solanaceous crops in Trinidad. Ann. Appl. Biol. 41: 240-247.
6. Freitag, J. H. 1941. A comparison of the transmission of four cucurbit viruses by cucumber beetles and by aphids. Phytopath. 31: 8. (Abstr.).
7. _____. 1952. Seven virus diseases of cucurbits in California. Phytopath. 42: 8. (Abstr.).
8. Hoggan, I. A. 1934. Transmissibility by aphids of the tobacco mosaic virus from different hosts. Jour. Agr. Res. (U. S.) 49: 1135-1142.
9. Larson, R. H., and J. C. Walker. 1939. A mosaic disease of cabbage. Jour. Agr. Res. (U. S.) 59: 367-392.
10. Sylvester, E. S. 1953. Host range and properties of Brassica nigra virus. Phytopath. 43: 541-546.
11. Walker, J. C., F. J. LeBeau, and G. S. Pound. 1945. Viruses associated with cabbage mosaic. Jour. Agr. Res. (U. S.) 70: 379-404.
12. Warid, W. A., and A. G. Plakidas. 1950. New viruses naturally infections to cowpea. Phytopath. 40: 30-31. (Abstr.).

FLORIDA AGRICULTURAL EXPERIMENT STATION, GAINESVILLE, FLORIDA

DECLINE OF STANLEY PRUNE TREES

K. D. Brase and K. G. Parker[1]

Abstract

Prune trees propagated on Myrobalan rootstock (Prunus cerasifera) with a leaf symptom termed chlorotic fleck made reduced growth. The Stanley variety grown on such stock developed a constriction at the bud union. Orchard trees with a similar constriction in severe form are killed. It is suggested that the Stanley variety may sometimes contain a factor that is lethal to the rootstock that is affected by chlorotic fleck but does not seriously affect normal stock.

In New York in recent years attention has been called to young Stanley prune trees with growth reduced in comparison with that of neighboring trees in the same orchards. The leaves often are rolled upward and may be yellowed (Fig. 1), and some affected trees eventually die. The weak trees usually are randomly distributed through the planting with no evident relation to differences in soil conditions.

Symptomatology and History

On vigorous trees in the plantings usually the bud union is smooth with no apparent difference in size of rootstock and scion. The weak trees show a prominent inverted shoulder at the union, with the main part of the rootstock immediately below the union smaller than the trunk above. Affected trees are weakly anchored in the soil as is usual when the root system is weakened by any cause. In severe cases there is a disruption in the bark at the union (Fig. 2). In the worst cases the bark just below the union becomes necrotic, followed by death of the entire root system.

The rootstock employed in propagating these trees is Myrobalan plum (Prunus cerasifera). Sprouts have arisen from the roots of some of the weakened trees, and they commonly bear leaves with chlorotic spots (Fig. 3) similar to symptoms described by Hildebrand (3) as asteroid spot. Since this term previously had been applied to a virus disease of peach (2), the writers consider that a different name should be given to this disorder of Myrobalan plum and therefore propose the name chlorotic fleck. Hildebrand reported reduced growth of affected seedlings and of Fellenberg prune budlings propagated on them.

In 1950, Brase (1) described a constriction disease of Stanley and observed that it appeared on trees planted in orchards since 1943. The inference was that something happened about 1940 to account for this trouble, that something was introduced into propagating material at that time. He suggested that a virus or virus-like factor may suddenly have appeared in the stock, possibly because of a change in the source of seed. Another suggestion was that the variety may have acquired an injurious entity that has been carried in budwood used thereafter for propagation in the nurseries. The latter situation seems somewhat similar to the problem with clone 227 of Northern Spy apple (4). When this clone was used as a rootstock for two different McIntosh clones, trees of one McIntosh clone died in a few years whereas trees of the other did not. Tukey and Brase (4) suggested the possibility that the uncongenial McIntosh clone may have carried a virus.

Propagation Trials

In 1950, two plantings of Myrobalan seedlings that differed markedly in expression of chlorotic fleck were encountered. At least 75 percent of the plants in one lot had well-developed symptoms, whereas very few trees in the other lot were affected. Stock was obtained from these two lots, and the following spring the two selections were planted in adjacent rows 4 feet apart, 8 to 10 inches apart in the row. At the usual budding season in August, two selections of Fellenberg prune and one each of Stanley prune and Abundance plum were propagated on these seedlings. There were 4 replicates of 5 seedlings each budded to each bud source. The bud

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[1] The authors wish to express their appreciation to Herman Cohn and Arthur Boller for providing planting space for the studies described, to Gustav Schmid and Dr. E. J. Klos for assistance in the work, to Dr. A. Frank Roos for helpful advice, and to Dr. G. C. Kent for critically reading the manuscript.

FIGURE 1. Stanley prune tree that was beginning to show decline, in the fourth year of growth. Note curled leaves and swelling just above bud union.

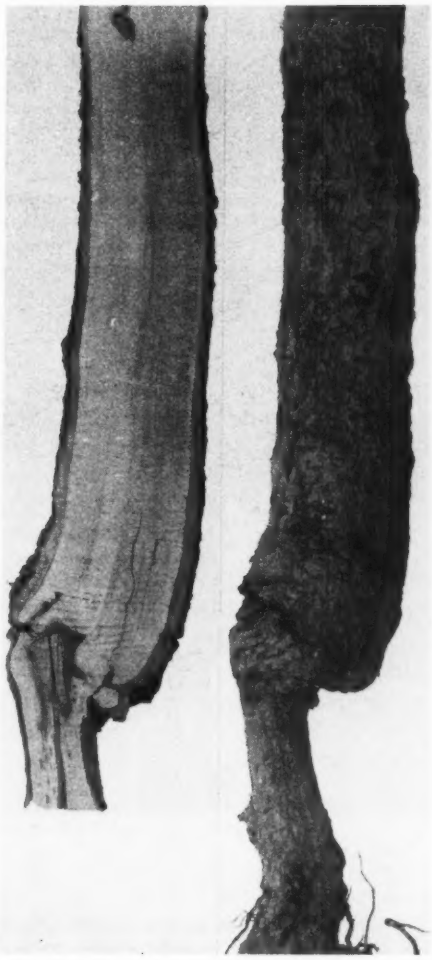

FIGURE 2. Bud-union area of a Stanley tree dug during the fourth year in the orchard.

sources were alternated along the row in each case.

At the end of each growing season the trunk circumference of each tree was measured at a marked point 3 1/2 inches above the bud union. The budlings were left in the nursery rows 3 years and then dug for examination of the roots and bud unions.

No measurable difference in size of trunk occurred the first year in the two Fellenberg selections on the two lots of stock; but both Stanley and Abundance, varieties typically more vigorous than Fellenberg, made more growth on the stock with light chlorotic fleck than on the more severely affected stock (Table 1). In the second and third years, all varieties grew better on the lightly-affected stock.

On the basis of ratings determined by eye, the constriction symptom was much stronger on Stanley on the stock with severe chlorotic fleck than on Stanley budded to the other stock. No such constriction was discernible on either Fellenberg or Abundance (Fig. 4). Another symptom observed was alternating longitudinal ridges and depressions on the stock immediately below the union, resulting in an appearance of angularity in cross section. This symptom was correlated

FIGURE 3. Attached leaves of Myrobalan plum showing chlorotic fleck.

FIGURE 4. Bud union on 3 varieties grown 3 years on Myrobalan seedlings affected by chlorotic fleck. Fellenberg prune on left, Stanley prune in middle, and Abundance plum on right. Constriction apparent only on Stanley.

Table 1. Growth of plum and prune on Myrobalan stock differing in severity of chlorotic fleck leaf symptoms[a].

Bud source	Circumference of trunk 3 1/2 in. above union, in cm			Rating for constriction at bud union[b]	Rating for angularity on stock[b]
	1951 (First year)	Increase 1952	Increase 1953		
On stock with severe chlorotic fleck					
Fellenberg-1[c]	4.00	2.21	2.02	0.0	0.25
Fellenberg-2[d]	4.70	2.67	2.24	0.0	0.46
Stanley	4.65	3.41	3.05	2.2	1.90
Abundance	5.03	3.16	2.09	0.0	0.69
On stock with very light chlorotic fleck					
Fellenberg-1	4.13	2.86	2.64	0.0	0.08
Fellenberg-2	4.88	3.39	3.34	0.0	0.46
Stanley	5.11	3.90	3.81	0.5	1.70
Abundance	5.67	4.10	3.06	0.0	0.69

[a] Each figure is average per tree of 4 replicates, each consisting of 1 to 5 trees.

[b] Rating by visual observation: 1 light, 2 moderate, 3 severe.

[c] A selection that indexed free of transmissible viruses (indexed on peach seedlings) but which has a severe leaf-casting mottle associated with reduced growth.

[d] A selection that indexed free of transmissible viruses but which has light leaf-casting mottle symptoms.

with budded variety and not with source of stock. It was very prominent on the stock on which Stanley was growing and much lighter on stocks budded to the other two varieties.

Discussion

Chlorotic fleck on leaves of the stock and reduced growth of budlings probably have a common cause. It should be pointed out that the seedlings with severe chlorotic fleck were smaller at the start, but this smaller size probably was caused by the disease and not by the soil conditions where they were grown. It is common observation that in seedling rows, or in lined-out stock, reduced size of seedlings is correlated with severity of the chlorotic fleck symptoms. Further, in the first year Fellenberg grew equally well on both lots of stock, with a difference in growth appearing in later years after the trees became well established in the new location where both lots were under similar conditions.

Tentatively, the authors suggest that chlorotic fleck in Myrobalan causes a reduction in growth of the budlings regardless of variety. If nothing else is involved, the only effect on the budling is reduced growth. There may be some factor in Stanley, however, that by itself causes the angularity of the stock without serious injury. Apparently, when this factor is combined with the one that causes chlorotic fleck a constriction is formed at the bud union, roots develop poorly, and some of the trees die.

It is recognized that conclusive proof of this tentative conclusion is lacking, and comments of other workers are invited.

Summary

Evidence is presented that Myrobalan stock with a leaf symptom termed chlorotic fleck supports reduced growth of budlings of plums and prunes. When Stanley prune was grown on this stock a constriction developed at the bud union. A similar constriction has been observed on orchard trees, and some severely affected trees have died.

Literature Cited

1. Brase, K. D. 1950. Failure of Stanley prune trees planted in recent years. New York Nursery Notes, No. 49 (January), p. 1.
2. Cochran, L. C., and C. O. Smith. 1938. Asteroid spot, a new virosis of the peach. Phytopath. 28: 278-281.
3. Hildebrand, E. M. 1945. Myrobalan mottle and asteroid spot. Phytopath. 35: 47-50.
4. Tukey, H. B., and K. D. Brase. 1944. Differences in congeniality of two sources of McIntosh apple budwood propagated on root-stock USDA 227. Amer. Soc. Hort. Sci. Proc. 45: 190-194.

DEPARTMENT OF POMOLOGY, NEW YORK STATE AGRICULTURAL EXPERIMENT STATION (GENEVA) AND DEPARTMENT OF PLANT PATHOLOGY, NEW YORK STATE AGRICULTURAL EXPERIMENT STATION (CORNELL)

LEAF VARIEGATION[1] IN STRAWBERRY - A REVIEW

George M. Darrow[2]

History of Variegation

Stevens (37) reviewed the literature on leaf variegation of the strawberry in 1933, when the trouble first appeared in the Blakemore variety. He classed this trouble with June yellows of the Howard 17 (Premier) variety and referred to an article by F. L. Sturtevant (see Hedrick, 20) in the Transactions of the Massachusetts Horticultural Society for 1888. The first record of variegated foliage noted by Sturtevant was in Fragaria vesca in 1719, when J. P. Tournefort listed the form F. vulgaris, variegato folio; the next in 1778, when "striped-leafed" forms of both F. vesca and F. virginiana and "white-" and "yellowstriped leafed" forms of F. moschata were referred to; and in 1832 a form of the cultivated strawberry, F. grandiflora, with leaves variegated with white was recorded.

The more recent references to variegation (Fig. 1) began in 1926, when Alderman (1) reported that the variety Minnesota (Pocomoke x Dunlap), distributed for trial in 1913 and named in 1920, had yellow foliage in several plantings the year it was named. By 1926, variegation in the Minnesota was so extensive that it was no longer recommended, but plants of Minnesota free from the trouble had been obtained and have remained free ever since.

In 1927 Berkeley (3, 4), reported variegation in Eaton, Grand Prize, Minnesota, and Waite's Everbearer and in seedlings at both Vineland and Ottawa, Canada, but not in the older commercial varieties. Badly affected plants gave practically no crop. After 3 years, Berkeley (5) had obtained no transmission and suggested that variegation is genetic in origin. He also noted that symptoms appear on the new unfolding leaves in spring and disappeared entirely in hot weather only to reappear on new leaves the next spring.

Plakidas (31) differentiated variegation from the virus disease xanthosis or yellows. He noted that the symptoms were most prominent in cool weather of spring; that the yellowing disappeared in late summer; that affected plants might have 90 percent of the leaf area yellow and devoid of chlorophyll and become dwarfed and, when dwarfed, produce very few berries; that all runner plants were affected (see Fig. 2); and that variegation occurred in the varieties Beaver, Eaton, Glen Mary, Howard 17, Mastodon, Peerless, Superb, Van Dyke, Wyona, "Seedling 5", and Vineland 2, 532, 192.

Clarke (7) reported on variegation in 1929, stating that it had been under observation for 5 years and that some plants of the Eaton variety had showed variegation (non-infectious chlorosis) about 5 years earlier but that all plants of Eaton had been variegated the next spring. He had noted variegation next in mid-summer 1927 in spring-set plants of Van Dyke (Ont. 19, 322, an open-pollinated seedling from a selection of the cross Dunlap x Early Ozark) and by the following spring all plants of it had been affected and some had died. He also had noted that variegation in each variety appeared in different parts of the country simultaneously. In 1929 he noted that some plants of Wyona and Superb and some seedlings of Wyona were affected and that in New England a number of fields of Howard 17 had the trouble.

In 1932 Plakidas (32) stated that all attempts to transmit "June yellows" by juice inoculation and leaf mutilation, by soil, by insects (white flies, leafhoppers, and aphids (Aphis forbesi and Pentatrichopus fragaefolia)) or bridge grafting, though 75 percent of the grafts had complete unions, failed. Stevens (37) reported that variegation appeared in Blakemore first in 1933 in Arkansas, Oklahoma, Maryland, Virginia, and North Carolina, and Plakidas (33) reported its appearance in Blakemore in Louisiana in 1933 also.

Guba (18,19) reported that in the late 1920's beds of Howard 17 completely free of variegation were uncommon. He also obtained no transmission by aphids, white flies, tarnished plant bugs, leafhoppers or red spiders, or by inoculation with sap, and effected no changes with fertilizers. He considered variegation a result of a recessive genetic factor, the expression of which was influenced by environment. Both Guba (19) and Berkeley published good illustrations.

Hedrick (21) reported variegation in many Howard 17 plantings, with 10 to 25 percent of the plants affected, and in Waite's Perfection, Aldrich, Haverland, and seedlings.

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[1] The term "variegation" is applied to the trouble variously called "June yellows," "spring yellows," "yellows," "chlorosis," "gold disease, suspected "mosaic," "transient yellows," and non-infectious leaf variegation."

[2] Principal horticulturist, Horticultural Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

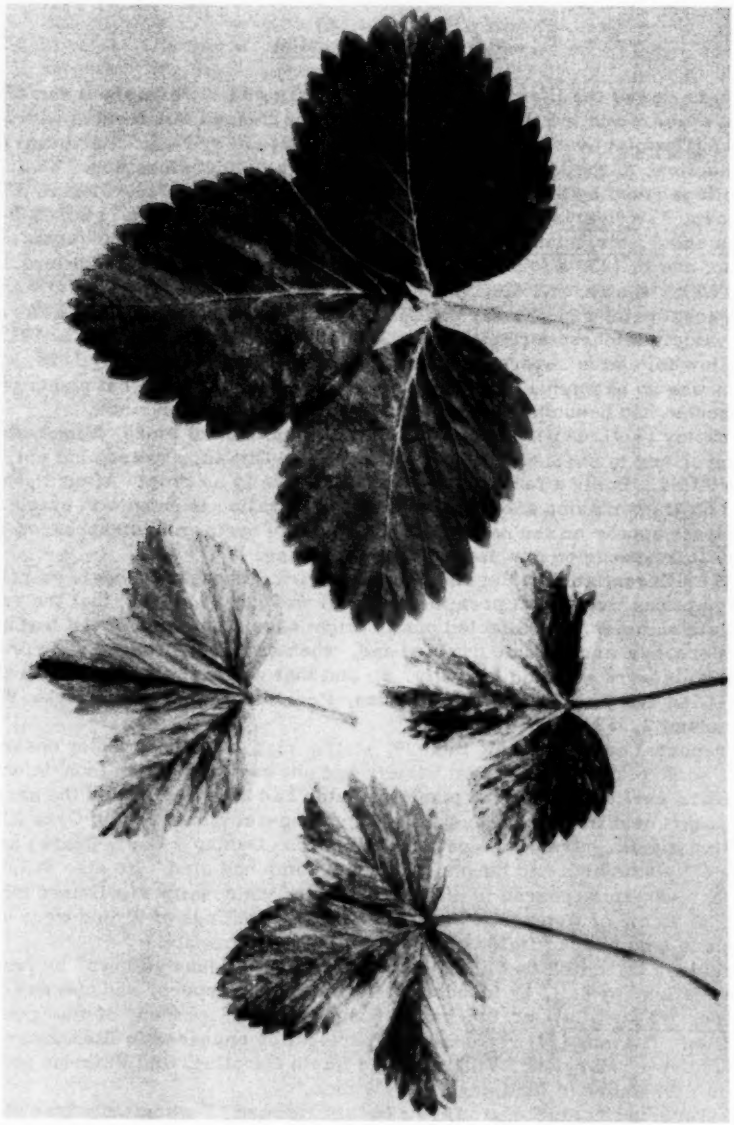

FIGURE 1. To right, normal leaf; to left, three smaller variegated leaves showing the streaking characteristics of this non-infectious trouble of the strawberry.

In 1934 Darrow (13) recorded the appearance of variegation in many varieties and selections. He had seen variegation in Benson, Moneymaker, Kellogg's Prize, Forward, Neverfail, Alden, Mascot, Francis, Gold Coin, and Big Lake [Big Late] varieties and in many selections. The variety Columbia was apparently so badly affected that it soon disappeared from cultivation. In early spring a French variety, received under the names "Merveille de France" and "Mirabilis", had a yellowing which disappeared in the summer. Variegation had been observed in Fragaria ovalis (F. cuneifolia) and in F. chiloensis in the wild in Oregon. Different degrees of yellow variegation had appeared in both varieties and selections, and white variegation had been noted, especially in Oregon. Variegation was considered to be due to mutation and to be a heritable character. In breeding work of the U. S. Department of Agriculture, variegated seedlings appeared almost every year; some seedlings had yellow cotyledons when they appeared above ground. Other seedlings did not show variegation until they had one, two, or even more leaves or not until they were set in the field or even later.

In 1935 Anderson (2) called attention to variegation in the Blakemore and stated that it seemed to be of genetic origin. He pointed out that new plantings should be made "only from mother plants which show no evidence of the disease."

In July 1935 the Arkansas Plant Board directed strawberry plant growers to dig out all yellow plants in their fields, stating that fields having more than 3 percent of yellow plants at the first inspection, during the week of July 15, would not be certified. Fields with 75 percent of the plants yellow were said by the Plant Board to be not uncommon.

In 1937 Demaree and Darrow (16) reported that variegation was serious in Blakemore and to a less extent in Howard 17. No variegation had been observed in Klondike, Missionary, Dorsett, Dunlap, Parsons Beauty (Gibson), Aroma, or Marshall. Demaree and Darrow also noted that no affected plants had ever recovered and that each variety had its own characteristic pattern of variegation. They, as well as Berkeley (3), Guba (19) and Plakidas (31), tried transmission by grafting but they too were unsuccessful. They noted that substitution of non-variegated stocks for variegated seemed to be a fully satisfactory method of control.

In September 1938 the Tennessee Department of Agriculture instructed its inspectors, beginning in the fall of that year, to refuse to certify Blakemore strawberry plants having over 5 percent variegation and to certify fields showing 5 percent or less only when they had been completely rogued. It also instructed them in 1939 to certify only fields propagated from the improved variegation-free strains.

In 1937 Pratt (35) noted that in Tennessee only one grower of Blakemore whose fields were free of variegation had been found. McUmber (27) called attention in December 1938 to this variegation-free Blakemore stock, which he had propagated and which had shown no variegation since it was started in 1931. This stock was largely substituted for other stocks in Tennessee and neighboring States. Later some variegation appeared in it.

Variegation was noted in Bellmar in 1940 (14) and in Progressive as early as 1925 (12).

Demaree (15) pointed out that leaf variegation differed with variety and season and was considered of minor importance until the introduction of Howard 17 and Blakemore, two widely grown varieties. He stated that most everbearing varieties possess the tendency to variegation. He recommended the use of strains or stocks comparatively free of this tendency to turn yellow as the only known way of overcoming the trouble. Posnette and Cropley (34) noted that "transient yellows" had occasionally been reported in Royal Sovereign and that the seedlings of the East Malling clonal Fragaria vesca sometimes develop streak. They had observed it in Perle de Prague, Mme. Lefebvre, Mme. Kooi (Moutôt), and Cambridge Favorite. They distinguished two stages, "transient yellows", which disappears during late May and June because of rising temperatures but frequently reappears in the autumn, and "streak" which appears on expanding leaves in the spring and persists as white or gray-brown streaks until the leaves die, only occasionally being seen on leaves emerging in late summer and autumn. Transient yellows in the autumn was invariably followed by streak the following spring, but streak also developed on plants not previously showing transient yellows. They obtained 34 percent larger plants and a 72 percent greater fruit yield from normal plants than from plants with "transient yellows." Klinkenberg (24) differentiated variegation ("spring yellows") from other troubles of Madame Moutôt.

Present Status of Variegation

The Auchincruive Climax variety, raised in 1939 and named and introduced in Scotland in 1947, quickly became the most important variety in Great Britain. Variegation, recognized as June yellows, was first noted in 1950 (34, 36), and by 1954 (22) it was so serious that questions

FIGURE 2. Variegation in Blakemore in Massachusetts. The row of variegated plants in the center were rooted from one variegated plant set in the spring. Rows of normal plants on either side were developed in the same way from single normal plants set in the spring.

regarding the future of the variety were being raised. First, "transient yellows" (June yellows) and later persistent yellows, or "streak", were noted. It was also noted that the trouble had been observed in seedlings raised in 1932 from the Dutch variety Madame Kooi (syn. of Mme. Moutôt) but had not been noted in Mme. Moutôt until about 1945 (24). It is now reported to be widespread in this variety in Europe.

Recently most of the stock of Wisconsin 537 strawberry has shown variegation, but a normal-appearing stock of it named Sharon may replace the mutating line.

Among the newly propagated virus-free stocks of strawberry varieties of the United States, variegation has appeared in only one -- a stock of virus-free Blakemore. Four other virus-free stocks of Blakemore that have not variegated have been propagated. Reserve stocks of each of these and of three virus-free stocks of Howard 17 have been kept separate so far so that any mutating stock can be quickly replaced.

Variegation has been observed in two other varieties by the author. It has been seen in the Chesapeake and at least once in Tennessee Beauty. In these two varieties variegation is apparently rare. Loomis (26) noted its occurrence in Klonmore.

The great variability in the expression of variegation was noted in 1931 by Clarke (9), who stated that some "seedlings are practically without chlorophyll, others have almost a normal amount while still others exhibit broad stripes of alternating green and chlorotic areas." This variability in seedlings, selections, and varieties has been typical. Furthermore, there seem to be great differences in the responses of varieties to temperature. At first the Howard 17 had June yellows, which disappeared in the hot weather of summer and reappeared on leaves developed in cool weather. Later, a streaked yellow and green variegation persisted all summer. In other varieties this persistent variegation is typical, but the colors are most vivid in spring. Whether there is or was in these varieties a "June yellows" stage that is temperature-limited is not known.

In September 1953 seeds of Fragaria vesca (var. Baron Solemacher) were sent to the Brookhaven, Long Island, laboratory for irradiation. In the various lots of seedlings grown from the irradiated seeds, 18 (6.5 percent) variegated mutants appeared. Only certain crowns were affected and these were overgrown by normal crowns unless the latter were removed. The variegations ranged from white to yellow, similar to those in naturally occurring mutants.

A spectrographic analysis of leaves from a normal green and a variegated plant of Blake-

more showed no difference in their Fe, P, Ca, Mg, or K contents, but the variegated leaves contained 19 percent more Cu, 13 percent more Mn, 120 percent more B, and 29 percent less Al than the green.

Inheritance of Variegation

In 1930 Clarke (8) reported that open-pollinated seedlings of Van Dyke were chlorotic and that variegation was inherited or the causal agent was carried in the seed. In 1931 (9) he called attention to the variability in expression of the trouble in different seedlings.

Clarke (10, 11) later reported that, when an affected Van Dyke plant was selfed, all the progeny were chlorotic in differing degrees but when a green Van Dyke was selfed only 24 percent were affected. When a green Van Dyke was pollinated by a yellow Van Dyke, 53 percent of the seedlings were yellow. When an affected plant was crossed with the normal green Aberdeen, 13 percent of the seedlings became yellow; in the reciprocal cross 10 percent of the seedlings became yellow. Some seedlings that were green the first year became chlorotic the next. No chlorotic plants reverted to normal green. The chlorotic condition appeared to be recessive and the green condition partly dominant. Plants heterozygous for this character may become chlorotic.

In 1937 Demaree and Darrow (16) noted that there was evidence that variegation was a mutation making possible the appearance of a recessive character. They reported that at Willard, North Carolina, 14 of 59 selfed Blakemore seedlings became variegated after being set in the field in 1936 and 1937, and at Beltsville, Maryland, 30 of 79 seedlings became variegated within two years in the field. They also suggested that growing large numbers of selfed seedlings might be used to predict the possible appearance of a variegated mutant in any variety. If variegated seedlings appeared in the seed flats the variety was presumed to carry variegation as a recessive gene. However, they warned that non-appearance of variegated seedlings should not be taken as final evidence that a complementary gene for variegation might not be present, for selfed Dorsett gave no variegated seedlings but crosses of Dorsett with other varieties gave 11 percent.

Drain and Fister (17) reported more than 25 percent of variegated seedlings in a small progeny of selfed Blakemore compared with 11 percent in a progeny of Blakemore backcrossed to Howard 17. In 1939, Clarke (11) reported that 101 of 16,711 seedlings grown at the New Jersey Station from 1930 to 1938 were variegated. Of this total 75 variegated appeared in 296 seedlings of 3 crosses and only 26 variegated in the remaining 16,415 seedlings. Clarke obtained no variegated plants among 16 selfed seedlings of Howard 17 but did obtain some in 14 of 21 progenies which had Howard 17 in their ancestry. When selfed, a green selection from open-pollinated variegated Van Dyke had 24 percent variegated seedlings while a variegated seedling of the same parentage had 100 percent variegated progeny. Jones and Singleton (23) obtained variegated seedlings in one inbred line of Howard 17, but none in inbred Chesapeake, Glen Mary, Marshall, or Progressive.

In the Netherlands Kronenberg (25) obtained 41 percent variegated seedlings of Mme. Moutôt, 24 percent of Blakemore, and 15 percent of Perle de Prague when she selfed them. When she crossed them with other varieties she obtained 8 percent variegated seedlings of Mme. Moutôt, 4 percent of Blakemore, and 2 percent of Perle de Prague. Brown (6), in England, obtained 4.6 percent variegated seedlings from normal Blakemore and 80.2 percent from affected Blakemore on selfing, and 1.2 and 61.0 percent, respectively, from normal and affected Howard 17 on selfing. Morris and Afanasiev (29) grew seedlings of non-variegated Progressive and all were free of the trouble, but most seedlings from variegated plants became variegated within two years. The Montana Progressive, an open-pollinated seedling of Progressive selected by them to replace. Progressive in 1935, had not variegated after 7 years.

In 1952 Morrow and Darrow (30) reported on variegation in inbred progenies. All progenies from Blakemore produced variegated seedlings, but in some progenies of backcrosses and sib-crosses there were few. In 2,411 (S_1, B_1, etc.) entirely of Blakemore parentage, 183 variegated seedlings appeared. No variegated seedlings appeared in the selfed seedlings of Daybreak, Eleanor Roosevelt, Fairfax, Fairmore, Massey or Southland, even though each, with the possible exception of Fairfax, had Blakemore or Howard 17 as a parent or a grandparent. Some of the S_1 progenies of Klonmore (22 in 374) and of Missionary (1 in 710) showed variegation. Although no variegated seedlings occurred in the S_1 progenies of Fairmore and of Massey, variegation appeared in two seedlings of a sib-cross of two selected S_1 of Fairmore and in one plant of a back-cross of an S_1 to Massey. Massey has not mutated to the variegated condition and very rarely does variegation appear in seedlings derived wholly from it. Morrow and Darrow also reported that in the sib-cross NC-1046 x NC-1045 the percentage of variegated seedlings was

almost 5 times as great as in the reciprocal. When these two selections were used as maternal parents in back-crosses to Blakemore, a similar difference was obtained.

Discussion and Conclusions

In the United States variegation probably caused the elimination of some strawberry varieties before the 1920's. Then in the early part of that decade the trouble appeared in the variety Minnesota, and a non-sporting stock of it found in 1923 or 1924 has remained normal ever since. Next in the mid-1920's variegation became widespread and serious in Howard 17, but normal green stock substituted for the mutating stocks in the late 1920's has given satisfactory control for the past 25 years. At approximately the same time -- 1927 to 1929 -- the Van Dyke (Ont. 19,322) mutated and no normal stock was found, and by 1932 it was discarded. In 1933 the major stocks of the Blakemore started such serious mutating wherever grown that for a time it appeared that the variety would be discarded although it constituted one-third of the total acreage grown in the United States. Normal-appearing stocks, first in Arkansas (28), then from Albany, Georgia, next from Greenfield, Tennessee, and recently from Beltsville, Maryland, have been substituted, so that now variegation causes little direct loss to growers. The most recent serious mutants are in Wis.-537, of which a normal-appearing strain has been propagated as the Sharon, and in Great Britain in Auchincruive Climax which many fear may be so seriously affected as to be lost. Temporarily, at least, selection of stocks that have not shown variegation has largely eliminated direct losses to growers in the United States.

A more serious, though indirect, loss due to variegation has been the elimination of seedlings and selections of certain crosses with high proportions of desirable genes. Thus, from the cross Blakemore x Dorsett many superior selections were made by Morrow and Darrow (30), but year after year additional seedlings became variegated and none were saved.

The evidence so far is that variegation is not due to a virus for after many trials by several workers it has not been transmitted. A similar variegation has been obtained when seeds have been irradiated. The evidence is that variegation is due to a frequently mutating or unstable gene and that the tendency to mutate is inherited as a recessive. Variegation is found in the diploid Fragaria vesca, which is considered to be close to the species from which octoploids are derived, as well as in all the hexaploid and octoploid species. Different varieties have different rates of mutating, and the strawberry seems to possess more than one gene for variegation. Its appearance is conditioned, to some extent at least by external conditions even though it may appear in all parts of the country at one time. Though variegation is due to a recessive gene or genes in an octoploid, it seems possible to breed this character out, as in Massey and Montana Progressive, or to minimize losses due to it. No sure test to determine whether a variety may mutate has been found but that suggested by Demaree and Darrow (16) -- growing large populations of selfed seedlings to observe whether recessives for variegation appear -- may help. Further observation and study are needed to determine the number of different types of variegations and the different appearances of each. Possibly of course some condition or conditions beside irradiation that induce variegation mutants may be found.

Literature Cited

1. Alderman, D. H. 1926. New fruits produced at the University of Minnesota. Fruit Breeding Farm, Minnesota Agri. Exp. Sta. Bul. 230: 1-47.
2. Anderson, H. W. 1935. Blakemore yellows. Illinois Hort. July.
3. Berkeley, G. S. 1928. Strawberry mosaic. Rep. Dominion Bot. (Canada): 1927: 128-130.
4. _____. 1929. Strawberry mosaic. Rep. Dominian Bot. (Canada): 1928: 125.
5. _____. 1931. Suspected strawberry mosaic. Rep. Dominion. Bot. (Canada): 1930: 125-126.
6. Brown, A. G. 1954. Strawberries. John Innes Hort. Inst. (England) 44th Ann. Rept.: 8-9.
7. Clarke, J. H. 1929. Non-infectious chlorosis of the strawberry. New Jersey Agr. Exp. Sta. Ann. Rep. 1929: 228-229.
8. _____. 1930. Non-infectious chlorosis of the strawberry. New Jersey Agr. Exp. Sta. Ann. Rept. 1930: 215.
9. _____. 1931. Non-infectious chlorosis of the strawberry. New

Jersey Agr. Exp. Sta. Ann. Rept. 1931: 279.
10. Clarke, J. H. 1933. Small-fruit investigations. New Jersey Bienn. Rept. 1932, 1933: 55-56.
11. _____. 1939. Prevalence of certain diseases affecting the foliage in some strawberry progenies. Proc. Amer. Soc. Hort. Sci. 36: 455-460.
12. Darlington, C. D., and K. Mather. 1950. The elements of genetics. London. 466 pp.
13. Darrow, Geo. M. 1934. Notes on variegated leaf troubles of strawberries. Plant Dis. Reptr. 18: 26-29.
14. _____, and J. B. Demaree. 1940. Leaf variegation or June yellows appearing in Bellmar strawberry. Plant Dis. Reptr. 24: 430-431.
15. Demaree, J. B. 1948. Diseases of strawberries. U. S. Department of Agriculture Farmers' Bul. 1891: 1-28.
16. _____, and Geo. M. Darrow. 1937. Leaf variegation in strawberry not considered a virus disease. Plant Dis. Reptr. 31: 400-403.
17. Drain, B. D., and L. A. Fister. 1937. Some strawberry progeny breeding data. Proc. Amer. Soc. Hort. Sci. 35: 60-66.
18. Guba, E. F. 1932. Strawberry gold disease. Massachusetts Agric. Exp. Sta. Ann. Rept. 1931 (Bul. 280): 204.
19. _____. 1933. Suspected mosaic of the strawberry. Phytopath. 23: 654-661.
20. Hedrick, H. P. 1919. Sturtevant's notes on edible plants. Albany, New York
21. _____. 1932. A mosaic-like strawberry disease. New York State Agr. Exp. Sta. (Geneva) Ann. Rept. 51 (1931-2): 33.
22. Howard, L. 1954. The rise and fall of Auchincruive Climax. The Commercial Grower (London), 26-28. July 2.
23. Jones, D. F., and W. R. Singleton. 1940. The improvement of naturally cross-pollinated plants by selection in self-fertilized lines. III. Investigations with vegetatively propagated fruits. Connecticut Agric. Exp. Sta. Bul. 435.
24. Klinkenberg, C. H. 1947. Eelworm disease of strawberries. Tijdschift over Plantenziekten LIII (4), 110-114.
25. Kronenberg, H. G. 1951. June yellows. Inst. V. de Veredeling van Tuinbouwgewassen, Meded. 1950: 104-105.
26. Loomis, N. H. 1948. Variegation in Klonmore strawberries. Plant Dis. Reptr. 32: 442.
27. McUmber, R. R. 1939. Yellows-resistant Blakemore strawberries. Proc. Tennessee State Hort. Soc. 34: 97-99.
28. Millar, P. H. 1937. Freedom from "yellows" of certain plantings of the Blakemore strawberry. Plant Dis. Reptr. 21: 70-71.
29. Morris, H. E. and M. M. Afanasiev. 1944. Yellows, a non-infectious disease of the Progressive everbearing strawberry in Montana. Montana State Agr. Exp. Sta. Bul. 424: 1-11.
30. Morrow, E. B., and Geo. M. Darrow. 1952. Effect of limited inbreeding in strawberries. Proc. Amer. Soc. Hort. Sci. 59: 269-276.
31. Plakidas, A. G. 1929. Report on strawberry virus disease project. Plant Dis. Reptr. 13: 129-131.
32. _____. 1932. The June yellows of strawberries. Phytopath. 22: 22.
33. _____. 1933. Leaf variegation of the Blakemore strawberry found in Louisiana. Plant Dis. Reptr. 17: 165-166.
34. Posnette, A. F., and R. Cropley. 1955. Strawberry yellows in the variety Auchincruive Climax. Jour. Hort. Sci. 30: 56-61.
35. Pratt, A. N. 1937. Are your Blakemore free from "yellow leaf?" Tennessee Hort., p. 5. July 15.
36. Reid, R. D. 1951. June yellows in Climax plants. Commercial Grower (London): 1056-1057. June 14.

37. Stevens, N. E. 1933. Leaf variegation appears in the Blakemore strawberry. Plant Dis. Reptr. 17: 145-147.

HORTICULTURAL CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE, BELTSVILLE, MARYLAND

VERTICILLIUM WILT OF STRAWBERRIES IN BRITISH COLUMBIA[1]

W. E. McKeen[2] and J. E. Bosher[3]

During the past few years, strawberry growers on the Saanich Peninsula of Vancouver Island and in the Fraser Valley of the mainland of British Columbia have become concerned about the wilting of strawberry plants (Figure 1). This wilting begins during the fruiting period. The plants often survive for a while and develop a few small leaves at the center of the crown and, often, one or more spindling side crowns, but produce little or no marketable fruit. Although development of the disease symptoms is usually gradual, instances of sudden wilt have been noticed.

FIGURE 1. A wilted strawberry plant with a healthy one on either side.

In June, 1953, a plantation at Saanichton, growing on sandy loam, was so severely affected that no marketable berries were harvested. Observations indicated that the disorder was not due to Phytophthora fragariae, virus, or leaf pathogen, but that root-lesion nematodes were present. Hence plots in the area were treated with methyl bromide at the rate of 2 pounds of Dow MC-2 per 100 square feet or ethylene dibromide at the rate of 33 gallons of Dow W-85 per acre. Comparable plots were retained as checks. After a 3-week fallow period, the check and treated plots were planted with healthy British Sovereign plants.

By late June, all plants had produced runners and appeared to be healthy, but suddenly the disease appeared throughout the check plots as well as in several spots in the plots that had been treated with ethylene dibromide. Black lesions appeared on the stolons, and the young, rooted runner plants collapsed, although the roots appeared quite healthy except for a few minute rust-colored lesions. The outer leaves of the parent plants first developed a dark green, water-soaked appearance. Upon close examination, small reddish-brown lesions, which later coalesced into extended, depressed, charcoal-black lesions, were observed on the petioles. The leaves then wilted and necrosis spread throughout the laminae. In late October, some disease symptoms appeared in the plots that had been treated with methyl bromide.

Since wilting was not controlled by Dow W-85, but was definitely checked with Dow MC-2, it became apparent that the disease was caused by a fungus rather than by nematodes. Numerous isolations showed that a Verticillium sp. was present in the crowns and petioles of wilting plants.

Surveys throughout the summer showed that wilt was present in a great many fields and was of major importance in some fields. Limited observations in the past and reports from growers suggest that Verticillium wilt of strawberries has been present for several years in

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[1] Contribution No. 1452 from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario.

[2] Plant Pathologist.

[3] Assistant Plant Pathologist.

British Columbia. A loss results not only from plants that die but also from the unproductiveness of infected plants that continue to live.

When healthy plants were grown in autoclaved soil inoculated with an isolate of Verticillium obtained from wilted strawberries, typical wilt symptoms were produced after six weeks. In experiments in which Wisconsin temperature-tanks were used, it was found that infected British Sovereign strawberry plants, whether or not they showed symptoms at time of transplanting from the field, succumb at 4°, 12°, 20°, and 28° C. It has also been shown that infection may occur over the same wide range of temperatures.

PLANT PATHOLOGY LABORATORY, SAANICHTON, BRITISH COLUMBIA

DRYLAND ROOT ROT OF 1953-54 WINTER WHEAT IN EASTERN NEW MEXICO

C. H. Hsi

Summary

The widespread occurrence of dryland root rot of winter wheat in eastern New Mexico in 1954 was caused by 1) environmental conditions conducive to the disease development 2) susceptibility of all commercial varieties grown in the area and 3) abundance of root rot organisms in the soil.

Collection of root rot affected plant samples and subsequent isolation of the root rot organisms from the infected roots were made in every month from September, 1953 to June, 1954.

Weather conditions, susceptibility of commercial wheat varieties and abundance and physiologic specialization of root rot organisms in the area complicate and render interesting the study of dryland root rot of winter wheat in eastern New Mexico.

As in the previous year, dryland root rot of wheat was again widespread in eastern New Mexico in 1954. The causes for this extensive occurrence were 1) environmental conditions conducive to the disease development, 2) susceptibility of all commercial varieties grown in the area[1], and 3) abundance of root rot organisms in the soil.

Conditions in the 1953-54 season which predisposed wheat plants to attack by root rot organisms were in most part similar to those reported earlier for the 1952-53 season[1]. They were 1) high planting temperatures, 2) much depleted sub-soil storage moisture, 3) severe drought during the growing season, and 4) exceedingly strong wind and blowing dust in early spring of 1954.

Table 1. The temperature data of August, 1953, and precipitation records for the periods from July, 1952 to June, 1953 and from July, 1953 to June, 1954 obtained at four weather stations in eastern New Mexico.

Weather Stations	Precipitation (inches) July, '53 - June, '54				Temperatures, August '53 (0° F.)				
	July, '52 - June, '53	Total	Greatest Month	Month	Average Maximum	Average Minimum	Average	Highest	Lowest
Cameron	8.65	11.64	4.04	July	89.1	59.6	74.4	99	51
Plains Substation	7.38	11.22	3.17	July	89.3	59.2	74.3	100	50
Clovis	9.57	12.53	3.23	August	89.4	62.1	75.8	98	57
Portales	13.75	9.89	2.88	July	91.5	63.5	77.5	101	58

[1] Hsi, C. H. 1954. Dryland root rot complex of winter wheat in eastern New Mexico. Plant Dis. Reptr. 38: 270-274.

Table 2. Fungi isolated from wheat samples affected with root rot in eastern New Mexico in every month from September, 1953 to June, 1954.

Fungus	Number of fields from which fungus was isolated										
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
Helminthosporium sativum	15[a]/20[b]	11/11	6/8	14/21	15/20	11/22	8/9	3/10	6/8	19/28	108/157
Rhizoctonia solani	11/20	1/11	7/8	20/21	15/20	20/22	2/9	10/10	2/8	15/28	103/157
Curvularia spp.	3/20	2/11	1/8	6/21	6/20	6/22	1/9	1/10	2/8	16/28	44/157
Fusarium spp.	3/20	4/11		3/21	6/20	10/22	2/9	3/10		7/28	38/157
Total	32/20	18/11	14/8	43/21	42/20	47/22	13/9	17/10	10/8	57/28	293/157

[a] Number of fields from which fungus was isolated.
[b] Actual number of fields surveyed.

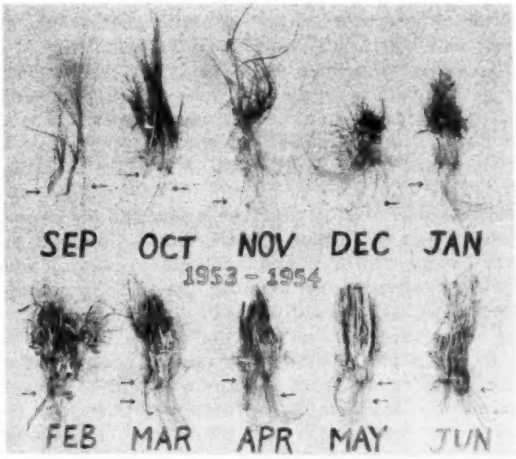

FIGURE 1. Wheat samples affected with root rot as collected in every month from September, 1953 to June, 1954 from the eastern New Mexico area. The arrow indicates the general area of infection by root rot organisms.

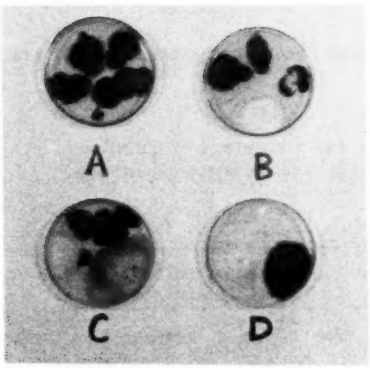

FIGURE 2. Root Rot organisms isolated from plated diseased wheat roots collected from the eastern New Mexico area.

A. Helminthosporium sativum
B. Top H. sativum
   Bottom Rhizoctonia solani
C. Top H. sativum
   Bottom Left R. solani
   Bottom Right Fusarium spp.
D. Left R. solani
   Right Curvularia spp.

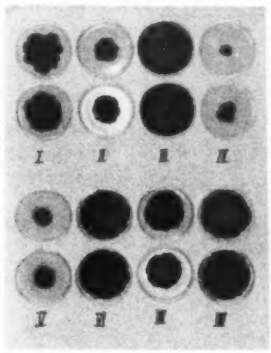

FIGURE 3. Eight of the many isolates of H. sativum obtained from the diseased wheat roots in separate localities of the Plains area. The isolates were grown on replicated potato-dextrose agar media incubated 14 days at 27 - 33° C.

Pertinent precipitation and temperature data from four weather stations in eastern New Mexico are given in Table 1. As shown in Table 1, only July and August had sufficient moisture for planting wheat successfully. Because of the moisture limitation in time of planting, and because of the need for green pasture in the fall, late planting as recommended in other areas for suppressing wheat root rot could not be carried out practically in eastern New Mexico.

In extremely dry years such as the ones just experienced in eastern New Mexico, estimation of wheat loss due entirely to root rot was difficult as drought in these years was the principal limiting factor in production.

However, it was conceivable that root rot further weakened the depressed wheat plants and in many instances hastened them to ultimate destruction. Comparisons were attempted between the healthy or disease-escaped plants and the infected plants, and in general root rot infected plants were found to be weaker in development, smaller in size, paler-green in color and with fewer tillers than the apparently healthy plants.

Repeated surveys of the area indicated that the root rot disease was present throughout the wheat growing season. Figure 1 shows the appearance of root rot symptoms on the infected plant samples as collected in every month from September, 1953 to June, 1954. The presence of wheat root rot in every month did not necessarily indicate, however, that the disease was actually initiated in each particular month, but rather that the disease was constantly present and that it could become active and destructive to the host plants whenever conditions were favorable for its development. In general, the earlier the establishment of the root rot infection, the greater damage the disease would cause to the well-being and economic value of the wheat plants.

The root rot organisms commonly isolated from the diseased plants in the area included Helminthosporium sativum, Rhizoctonia solani, Fusarium spp. and Curvularia spp. Figure 2 shows the appearance of these fungi on potato-dextrose agar at 24° C. The relative frequency of isolation of these same root rot organisms within each month during the period from September, 1953, to June, 1954 is given in Table 2. On the basis of the total frequency of isolation in 1954, the root rot organisms ranked in the following order: H. sativum 108 times, R. solani 103, Curvularia spp. 44, and Fusarium spp. 38.

Physiologic specialization occurred in all of the known root rot organisms in the area.

Table 3. Mean lengths, widths of 100 spores and diameters of colonies of eight local isolates of H. sativum grown on potato-dextrose agar after 14 days at 27 - 33° C.

Isolate	Location	100-spore measurement in microns		Diameter of colony in millimeters		
		Mean Length	Mean Width	Rep 1	Rep 2	Average
I	Plains Substation	48.25	14.67	69	66	67.5
II	S.W. Pleasant Hill	54.25	16.40	40	50	45.0
III	W. Grady	47.75	15.17	90+	90+	90.0+
IV	N. Wheatland	35.95	12.82	19	31	25.0
V	N. Clovis	28.20	11.65	29	33	31.0
VI	Bellview	41.90	14.52	85	86	85.5
VII	N. Inez	50.30	14.32	72	62	67.0
VIII	E. Dora	35.45	13.95	83	83	83.0

Over 100 different isolates were obtained and maintained individually in pure cultures. The appearance of eight of the many distinct isolates of H. sativum is shown in Figure 3. These isolates were grown on replicated potato-dextrose agar media at 27° to 33° C. for a period of 2 weeks. The mean measurements of 100 spores and the diameters of colonies of these eight isolates are included in Table 3.

In conclusion, the unique weather conditions, total susceptibility of commercially grown wheat varieties, and abundance and physiologic specialization of root rot organisms in the area complicate and render interesting the study of dryland root rot of winter wheat in eastern New Mexico.

NEW MEXICO AGRICULTURAL EXPERIMENT STATION, PLAINS SUBSTATION, CLOVIS

THE CONTROL OF DWARF BUNT OF WINTER WHEAT WITH CHEMICAL SEED TREATMENTS

S. G. Fushtey

The control of dwarf bunt in winter wheat presents a particularly difficult problem because of the persistent nature of the soil-borne inoculum. No chemical seed treatment has yet been found to be effective against this source of infection. However, the spores of the dwarf bunt fungus (Tilletia brevifaciens) are also seed-borne and the disease is undoubtedly spread by means of infested seed. Work in both Europe and North America has shown that certain chemicals, when applied to infested soil, provide a considerable degree of disease control but there are no data available, as far as the writer is aware, on the effect of chemicals applied to the seed for control of the seed-borne inoculum.

Exploratory seed-treatment tests were conducted in 1954-55 using the following four fungicides: Ceresan M, Panogen, Tritisan, and Anticarie. Dwarf bunt spores collected in 1954, and confirmed viable by previous germination tests, were applied to wheat seed at the rate of 1 gm. per 100 gm. seed. The fungicides were applied to the infested seed at two rates: 1) That recommended by the manufacturer, 2) Double the recommended rate. The treated seed was then kept in covered flasks to be sampled after different periods of storage. Following each desired storage period 20 gm. portions of the seed were transferred to clean flasks and each shaken with 20 ml. of water to wash off the spores; 10 ml. of the resulting spore suspension were then transferred to individual glass tumblers half-full of moist soil and these incubated in a Wisconsin temperature tank maintained at about 5° C. At weekly intervals, small samples of the spore-soil mixture were taken from the surface of the tumbler cultures and examined microscopically for spore germination. During the preparation of these samples the germ tubes and sporidia became detached from the spores so that germination could not be expressed on a percentage basis; rather, an estimate of the relative abundance of sporidia produced was taken as an index of spore germination. The results obtained after 10 weeks incubation are presented in Table 1.

Table 1. Effect of seed treatment chemicals on the germination of seed-borne dwarf bunt spores in soil medium incubated at 5° C. for 10 weeks.

Treatment[a]	Rate per bu.	Germination rating[b] Storage period after treatment			
		1 day	2 days	4 days	8 days
Ceresan M	1/2 oz.	+	++	+	+
"	1 oz.	0	+	+	+
Tritisan	1/2 oz.	0	0	0	0
"	1 oz.	0	0	0	0
Anticarie SD	1/2 oz.	0	0	0	0
"	1 oz.	0	0	0	0
Panogen 15	3/4 oz.	0	0	0	0
"	1½ oz.	0	0	0	0
Check	-	+[c]	++	++	++

[a] Active ingredients: Ceresan M = 7.7% ethyl mercury p-toluene sulfonanilide. Tritisan = 60% pentachloronitrobenzene. Anticarie SD = 40% hexachlorobenzene. Panogen 15 = 2.2% methyl-mercury dicyandiamide.

[b] 0 = no sporidia; + = few sporidia; ++ = abundant sporidia.

[c] Too much water added to all "1 day storage" preparations. Soil was saturated throughout the experiment and sporidial production was poor.

While the data in Table 1 were obtained from microscopic examinations at the end of a 10-week incubation period the first signs of germination appeared considerably earlier with sporidia occuring in the check treatments after incubation for only 3 weeks. At 4 weeks the checks contained abundant sporidia and some germination was also evident in the Ceresan treatments.

The results clearly show that Ceresan M did not prevent spore germination even when applied at double the recommended rate. Tritisan, Anticarie, and Panogen completely prevented germination during the 10-week incubation period. This latter result indicates that proper seed treatment may help control dwarf bunt by preventing its spread with the seed even though it cannot protect the crop against soil-borne inoculum.

DEPARTMENT OF BOTANY, ONTARIO AGRICULTURAL COLLEGE, GUELPH, ONTARIO, CANADA

STALK ROT OF CORN IN NEW YORK, 1954

Carl W. Boothroyd, Harley J. Otto, John M. Barnes[1]

A preliminary survey was made of stalk rot of grain corn in nine New York State counties at harvest time during the fall of 1954. A total of 37 different farms were visited, and as many as 41 corn hybrids were examined. Most of the growers on these farms reported a previous history of stalk rot of corn, or suspected that the disease was present. Actual counts were made of diseased and healthy plants, soil samples were collected for analysis, and records were taken on previous cropping practices, fertilizer programs, soil types and drainage, and planting dates.

The percentage of stalk rot ranged from 0 to 89 averaging about 35. Half of all farms visited had over 30 percent diseased plants. Stalks still standing in the fields, even though weakened by rotting of the lower portions, were included in these percentages. Grain on most of these erect plants was being harvested, but many of the stalks undoubtedly fell down before the ears could be harvested. Grain on plants on the ground was particularly difficult to recover because the stalks had fallen in many different directions. Even the diseased stalks still standing made mechanical picking difficult; whole plants were swept aside or clogged the picker because of rotted root systems.

Very few comparisons among corn hybrids could be made because of the practice of planting whole fields to one or two hybrids. In general, however, hybrids recommended for resistance to stalk rot in New York State proved better than those with known susceptibility. Early-maturing hybrids had more stalk rot than late-maturing ones. Many of the late-maturing hybrids which showed very little stalk rot were not ripe enough to harvest, however, and those which were mature enough required artificial drying of the grain.

In isolations made from diseased stalks collected on the different farms, Gibberella zeae (Schw.) Petch was recovered most consistently. G. fujikuroi (Saw.) Wr. was the next most common fungus recovered. Diplodia zeae (Schw.) Lév., the primary cause of stalk rot in other corn regions, was not found.

No one factor or combination of factors could be found directly responsible for the severity of stalk rot. Corn following corn was no worse in percentage of stalk rot than corn after grain, or corn following a legume or legume and grass rotation. Different manuring practices neither increased nor decreased the incidence of stalk rot. Although a variety of commercial fertilization programs were employed in the various counties, no one practice could be found responsible for increasing the severity of the disease.

Light sandy loam soils proved to have just as much diseased corn growing on them as did heavier clay loams. Analysis of the soil samples collected showed no positive correlation between stalk rot and pH, or the nitrogen, phosphorus, or potassium content of the soil.

DEPARTMENT OF PLANT PATHOLOGY, CORNELL UNIVERSITY, ITHACA, NEW YORK

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[1] Respectively, Associate Professor, Department of Plant Pathology, Research Assistant, Department of Plant Breeding, and Research Assistant, Department of Plant Pathology, Cornell University.

CORN DISEASES IN IOWA NURSERIES IN 1953 AND 1954[1]

A. L. Hooker[2]

Abstract

A corn nursery employed for simultaneous evaluations for resistance to several disease and insect pests is described. Observations on disease development in this and adjacent nurseries are reported. Field and greenhouse evaluations with Puccinia sorghi Schw. suggest that both protoplasmic and mature-plant types of resistance occur in corn.

In a recent paper[3] the author reported on the relative efficiency of various methods of inducing field infections on corn in central Iowa with Helminthosporium turcicum Pass. and Puccinia sorghi Schw. It was suggested that a low lying isolated area be selected for a disease nursery, in the corn breeding program, and that artificial humidity be created to facilitate infections by these pathogens. The present paper reports observations on corn diseases in such a nursery in 1954 and in adjacent nurseries in 1953 and 1954.

The area used for the nursery in 1954 consisted of a 15-acre plot, situated near a creek, and bordered by higher ground on the south and north and by trees on the west. Silage corn was grown the previous year. Approximately 8 acres were employed as a corn nursery in 1954 and half of this area was used for disease evaluations. The remaining portion was planted to soybeans as a green manure crop in a two year rotation.

Abundant rainfall occurred during April, May, and the early part of June, while no appreciable amount of precipitation occurred from the last of June to the first part of August. From the middle of August until the first part of September several heavy rains occurred. The nursery was flooded for approximately 18 hours when the corn was 3 to 6 inches high and again just following pollinations.

Additional artificial humidity was provided in the nursery through the use of a portable fogging machine. This machine delivered water at the rate of 700 gallons per hour as a fine mist into an air blast, which further broke up the droplets into a fine fog, and dispersed them within an area of approximately 100 feet from the side of the machine. The machine in operation was pulled around the plot for an hour before sunset at weekly intervals during June and July. The normal downward temperature gradient aided in maintaining moisture on the plants over night.

Leaf Blight

Inoculum of Helminthosporium turcicum was applied in the leaf whorl in the form of ground infected leaves collected the previous season. As an insufficient amount of this dry material was available for the area to be inoculated, it was supplemented by leaf whorl applications of conidial and mycelial suspensions in water. Early and abundant primary lesions were produced, offering some opportunity for selection at pollination, but maximum secondary spread did not occur until the latter part of August. In early September, all of the leaves of susceptible material were heavily blighted while leaves of resistant material showed only scattered lesions. Leaf blight ratings at this time were believed to be reliable as susceptible checks showed a high level of disease and consistent scores were obtained in replicated experiments.

Rust

An epiphytotic of leaf rust incited by Puccinia sorghi was created in this nursery by hypodermic inoculations of spreader rows with a water suspension of urediospores. These spreader rows consisted of a mixture of susceptible corn strains and ran crosswise of the field so that

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[2] Formerly Assistant Professor, Department of Botany and Plant Pathology, now Agent (Plant Pathologist) Cereal Crops Section, Agricultural Research Service, U. S. Department Agriculture, Madison, Wisconsin.

[3] Hooker, A. L. 1954. Relative efficiency of various methods of inducing field infections with Helminthosporium turcicum and Puccinia sorghi. Plant Dis. Reptr. 38: 173-177.

one hill of the spreader occurred at the end of each nursery row. Abundant sporulation occurred on the susceptible spreader. Infections on the nursery material gradually built up until early September when notes were taken. Slight differences in infection due to position of plant in the nursery row were noted early in the season but these disappeared as the epiphytotic progressed. It was possible to make some selection for resistance at pollination but maximum differences were not expressed until September. At this time leaves of susceptible material were 60 percent covered with rust pustules and many plants were killed. Infection percentages ranged down to a trace where only a few rust pustules could be found in a nursery row.

In 1953, rust was generally prevalent throughout the various corn nurseries on the Iowa Agricultural Experiment Station. This epiphytotic occurred naturally and started early in the season. When rust ratings were taken in these various nurseries, wide variations in infection percentages were found among corn strains. One hundred and sixty strains were selected which exhibited less than 1 percent or a trace of rust in this natural epiphytotic. These strains were then evaluated, in greenhouse seedling tests, for resistance to 18 cultures of rust, obtained from uredial collections in several locations throughout the United States and Mexico and from aeciospores. Thirty-five strains or 22 percent of those tested exhibited protoplasmic resistance (chlorotic to necrotic -- 0; to 1- pustule types) to one or more biotypes of the pathogen.

When these strains with seedling protoplasmic resistance were planted in the field in 1954 they remained rust free, while adjacent strains, known to have been susceptible in the field in 1953 and susceptible as seedlings to the rust biotypes tested, showed various percentages of rust. Other strains which showed no protoplasmic resistance in the seedling evaluations, but were relatively rust free in the field in 1953, were also relatively rust free in 1954.

Numerous corn strains expressing protoplasmic resistance in the seedling stage, to a range of fungus biotypes, and other strains, not expressing such resistance, were inoculated hypodermically with these biotypes in the field in July just prior to stem elongation. These strains at this stage of growth expressed the same disease reaction as they did as seedlings. Rust continued to develop only on the susceptible strains during the remainder of the growing season.

These data suggest that two types of resistance to rust exist in corn: 1) protoplasmic resistance which is expressed at all plant stages, and 2) mature-plant resistance which is expressed only by the mature plant in the field.

Stalk Rot and Crazy Top

Diplodia stalk rot evaluations were employed by injecting a spore suspension of Diplodia zeae (Schw.) Lév. into the stalk following pollination. At harvest the stalks were cut longitudinally and relative spread of the pathogen noted. Resistant strains showed less than half of the inoculated internode discolored by the fungus.

Numerous plants in the nursery exhibited crazy top (presumably incited by Sclerophthora macrospora (Sacc.) Thirum. et al[Sclerospora macrospora Sacc.]) symptoms of various degrees and types. Although frequently two or more plants of the same nursery row expressed symptoms while plants in adjacent rows expressed none, it was not felt that this was sufficient evidence of host resistance. The appearance of crazy top in this nursery following flooding in the seedling stage lends further support to Ullstrup's[4] observations.

European Corn Borer

In addition to disease evaluation, evaluations for resistance to the leaf feeding stage of the European corn borer (Pyrausta nubilalis Hübner) were conducted in the same nursery[5]. Satisfactory corn borer evaluations were obtained in the presence of the leaf blight and rust diseases.

Discussion

A nursery of this type presents a unique opportunity to select simultaneously for resistance to numerous disease and insect pests of corn, occurring naturally and artificially, along with the usual selection for desirable agronomic characteristics. Auxiliary tests on seedling diseases, grain quality, and others can supplement the observations and selections in the nurs-

[4] Ullstrup, A. J. 1952. Observations on crazy top of corn. Phytopath. 42: 675-680.

[5] Dicke, F. F., and L. H. Penny. 1952. Built in resistance helps corn fight borers. Crops and Soils. Aug. - Sept. pp. 9-11.

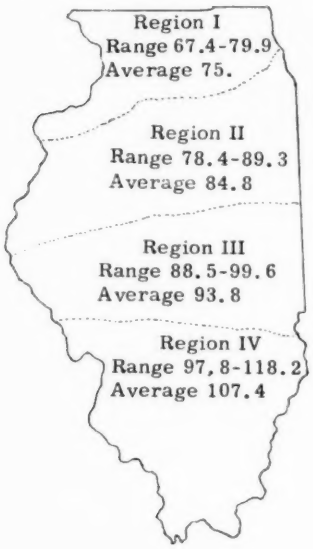
ery. It is felt that greater progress can be made in a corn breeding program by these annual, early, and simultaneous disease and insect evaluations.

IOWA AGRICULTURAL EXPERIMENT STATION, AMES, IOWA

STEWART'S DISEASE PROSPECTS FOR 1955 IN ILLINOIS

G. H. Boewe

In 1955, Stewart's disease, or bacterial wilt (Bacterium stewartii), of corn probably will be less destructive and will not occur as far north in Illinois as it did in 1953 or 1954.



Two principal types of damage to corn are produced by Stewart's disease: an early season wilt and death of plants, especially in sweet corn, and a late season leaf blight, which may be severe enough to cause premature death of plants. The wilt and leaf blight phases of the disease are expected to appear on susceptible corn in Illinois as shown by the table below.

Region	Early season wilt	Late season leaf blight
I	None	Trace at most
II	Absent or nearly so	Light to severe
III	Light to severe	Severe
IV	Destructive	Severe

The four regions are delineated on the map at the left. These regions have been determined on the basis of winter temperature indexes (the sum of the mean temperature of December, January, and February of the past winter) calculated from the records of 85 weather reporting stations in the state. The data were obtained from the U. S. Weather Bureau office at Champaign. The range of indexes and an average index are shown for each of the four regions.

As indicating the future occurrence of Stewart's disease, these indexes appear to have significance as follows:

If the index is	Early season wilt probably will be	Late season leaf blight probably will be
100 or more	Destructive	Severe
Between 90 and 100	Light to severe	Severe
Between 80 and 90	Absent or nearly so	Light to severe
Below 80	Absent	A trace at the most

The chief means of overwintering of Stewart's disease is in the bodies of adult corn flea beetles. Research conducted in Illinois in 1954 by entomologists of the Illinois Natural History Survey indicates that dieldrin is very effective in controlling the corn flea beetles. Based upon this work, the following experimental dosages of dieldrin are suggested by our entomologists. In areas where corn flea beetles are constantly a problem apply 1 1/4 to 1 1/2 pounds of actual dieldrin per acre and work into the upper few inches of soil just before planting. Where soil treatment was not made and flea beetles appear, apply 1 1/4 pound actual dieldrin, banded over the row, as a foliage spray when the beetles first appear. If the dieldrin is applied broadcast over the field use 0.4 pound actual dieldrin per acre.

Adult flea beetles can be controlled by applying DDT at the rate of 1 1/2 pounds per acre, but this treatment does not have the residual effectiveness of dieldrin. Data indicate that 5 to 7 applications of DDT at the above strength will greatly reduce the incidence of Stewart's disease. DDT should be applied weekly beginning when flea beetles first appear on the seedling plants and continued as long flea beetles are present.

This forecast on Stewart's disease, the seventh to be made for Illinois, is based upon the close relationship that appears to exist between the amount of disease which develops during the summer and the temperature of the preceding winter. In general the development of both phases of the disease, especially on sweet corn during this period, coincided very closely with the pre-

dictions made in the first six forecasts. Recent surveys made in Champaign County show that many corn flea beetles survived the past winter and the extremely low temperatures of late March 1955. However, it has been recognized that other unknown factors, in addition to winter temperatures, may influence survival of corn flea beetles. Although corn flea beetles were abundant in central Illinois in April of 1954, there were very few beetles present here and at East St. Louis in May when the corn came up. As a result, early season wilt was much less severe than expected except in localized areas.

ILLINOIS STATE NATURAL HISTORY SURVEY, URBANA

CONTROL OF STEWART'S BACTERIAL WILT OF CORN BY FOLIAR APPLICATION OF STREPTOMYCIN SPRAYS[1]

John J. Natti

SUMMARY

Growth of Bacterium stewartii was inhibited in filter disc assay tests by STS and Agrimycin at dilutions containing active streptomycin at 100, 50, 25, and 10 ppm. Inhibition was slight at 10 ppm. In broth dilution tests, Agrimycin inhibited growth of Bacterium stewartii at dilutions ranging from 500 to 3.9 ppm of active streptomycin, but not a dilution of 1.9 ppm.

In field tests conducted in 1954, one and two foliar spray applications of five different streptomycin preparations, each at a concentration of 100 ppm of active streptomycin, exerted no apparent therapeutic effects in sweet corn seedlings naturally infected by Stewart's wilt bacteria. However, the streptomycin sprays did provide some control of the spread of wilt at each of three plantings in which the incidence of wilt at the time of the application of the streptomycin sprays averaged 8, 12, and 19 percent. On the basis of the number of wilt-infected plants counted in the plots at the date of application of sprays and the number of infected plants in the same plots 18 to 25 days later, the increase in incidence of wilt between these dates averaged 7 to 11 percent in plots sprayed with streptomycin and 19 percent in unsprayed plots.

INTRODUCTION

The potential value of antibiotics applied as foliar sprays for the control of bacterial diseases of plants is indicated by the ever-increasing accumulation of evidence from tests on various crops and pathogens. Streptomycin has been applied as a foliar spray to control bean halo blight (Pseudomonas phaseolicola) (9), apple and pear fire blight (Erwinia amylovora) (3, 4, 7, 10), pepper and tomato bacterial spot (Xanthomonas vesicatoria) (2), and tobacco wildfire (Pseudomonas tabaci) (1, 5, 8).

The general occurrence of Stewart's bacterial wilt (Bacterium stewartii) in early plantings of sweet corn in New York during 1954 provided an opportunity to conduct tests on the control of this disease by streptomycin applied as a foliar spray. The object of these tests was to determine whether streptomycin sprays would eradicate the disease from naturally infected corn seedlings scattered throughout field plantings. Although the streptomycin sprays failed to exert any apparent therapeutic effects against established infections, the treatments did provide some protection against new infections.

PROCEDURE

The activity of streptomycin and of Agrimycin (15.0% streptomycin and 1.5% Terramycin) against Bacterium stewartii, the causal organism of Stewart's bacterial wilt, was assayed by the filter disc and the broth dilution methods. In the filter disc assay method, 24-hour cultures of two pathogenic isolates of the wilt organism grown on TGYE (tryptone glucose yeast-extract) broth at 32° C. were swab-streaked on TGYE agar in petri plates. A 12.5 mm. filter disc was placed on the agar and 0.1 ml. of the streptomycin test preparation at the desired dilution was pipetted to each disc. The plates were incubated for 24 hours at 32° C. and the diameter of the zone of inhibition in each plate was then measured. This diameter measurement included the distance from one outer limit of the inhibition zone, across the center of the filter disc, to the outer limit of the inhibition zone on the opposite side. In the broth dilution method, dilutions of Agrimycin were added to tubes of TGYE broth containing the wilt bacteria. After 24 hours of incubation at 32° C. the tubes were examined for inhibition of growth.

Field tests were conducted at three locations in central New York. At each location, a 4-row strip, 500 feet in length in an extensive planting of sweet corn (North Star), was divided into 24 plots, each consisting of a 40-foot length of two adjacent rows. The total and the number of Stewart's wilt-infected corn seedlings in each plot were counted and each infected plant was marked with a stake. The corn seedlings at this time were 6 to 10 inches in height and

[1] Published with approval of the Director, New York State Agricultural Experiment Station, Geneva, New York, as Journal Paper No. 997.

Table 1. Activity of streptomycin and Agrimycin against two isolates of Bacterium stewartii as indicated by filter disc assay method.

Antibiotic[a]	Dilution ppm[b]	Diameter of inhibition zone (mm.)[c] Isolate G-13	Isolate 0-1
STS	100	20	24
	50	18	19
	25	16	17
	10	14	15
Agrimycin	100	25	24
	50	23	19
	25	20	17
	10	16	14

[a] STS, streptomycin sulfate supplied by Merck and Co., Inc. Agrimycin supplied by Chas. Pfizer and Co., Inc.

[b] ppm of active streptomycin.

[c] diameter of inhibition zone includes 12.5 mm. diameter of filter disc.

were infested with the corn flea beetle (Chaetocnema pulicaria), the chief vector of the wilt bacteria. After the plants were counted the plots were sprayed with the streptomycin preparations.

Five different streptomycin preparations were tested. Spray suspensions containing active streptomycin at a concentration of 100 ppm were prepared by adding the required amount of the antibiotic to 5 gallons of water containing 3 ml. of Triton B1956, a wetting agent. Immediately upon preparation of the spray suspensions, the antibiotics were applied to the foliage of the corn seedlings by means of a tractor-mounted sprayer equipped to spray two rows at a time with one overhead T-jet #8001 nozzle to each row. The sprayer was calibrated to deliver 55 gallons of spray per acre at 200 pounds of air pressure when operated at a tractor speed of 1.5 miles per hour. The plots at two locations received a single application on June 12, whereas the plots at the third location were sprayed twice, June 13 and June 17. The temperatures ranged between 70° to 76° F. at the time of the spray applications. The treatments were randomized and replicated four times at each location. Unsprayed plots served as controls.

The entire plantings at each location were sprayed periodically with DDT to control the flea beetles. The first DDT spray was applied about 24 hours after the first streptomycin application. Since the DDT effectively controlled the flea beetles, transmission of the wilt bacteria to healthy plants in the plots after initiation of the tests was restricted for the most part to the interval between the streptomycin sprays and the first DDT spray.

The number of infected plants in each plot were counted again 18 to 25 days after the application of the streptomycin sprays. Infected plants were observed periodically throughout the season for wilt symptoms and also examined for the presence of bacteria in the vascular tissues.

RESULTS

In the filter disc antibiotic assay test, growth of the two isolates of Bacterium stewartii was inhibited by STS and Agrimycin at dilutions containing active streptomycin at 100, 50, 25, and 10 ppm (Table 1). Inhibition was slight at 10 ppm. With isolate 0-1, the degree of inhibition provided by the various dilutions of STS and Agrimycin was identical. With isolate G-13, Agrimycin was more effective than STS. In the broth dilution tests, growth of isolate G-13 was inhibited by Agrimcyin at active streptomycin concentrations of 500, 250, 125, 62.6, 31.2, 15.6, 7.8, and 3.9 ppm, but not at 1.8 ppm.

The incidence of wilt-infected plants in the test plots at the date of the initial count averaged 19 percent at Location 1, 8 percent at Location 2, and 12 percent at Location 3 (Table 2). None of the streptomycin preparations exhibited discernible therapeutic activity against established infections. Wilt-infected corn seedlings sprayed with streptomycin either remained in-

Table 2. Incidence of Stewart's bacterial wilt of sweet corn in field tests at time of foliar application of streptomycin sprays and 18 to 25 days after application of sprays

Treatments[a]	Gm. in 5 gal.	Total Plants and Number Infected[b]									Percentage increase in number of infected plants[c]
		Location 1			Location 2			Location 3			
		Total	Infected		Total	Infected		Total	Infected		
		6/12	6/12	6/30	6/12	6/12	6/30	6/13	6/13	7/8	
Strep. STS	3.5	327	59	108	285	17	35	237	53	62	9
Strep. STC	22.7	318	53	91	313	30	50	239	24	41	9
Strep. STB	22.7	298	62	111	294	29	55	271	34	50	11
Strep. Broth	18.8	303	61	94	297	23	50	241	25	30	7
Agrimycin	13.3	298	57	80	296	21	51	236	18	28	8
No treatment	—	306	57	124	309	23	71	231	20	68	19
Total		1850	349	608	1794	143	312	1455	174	279	
LSD 5%											4
1%											6

[a] Streptomycin STS, STC and STB supplied by Merck and Co., Inc.; Streptomycin Broth supplied by Mathieson Chemical Corp.; Agrimycin supplied by Chas. Pfizer and Co., Inc. All treatments applied at a concentration of 100 ppm of active streptomycin, one spray application at Location 1 and 2; two applications at Location 3.

[b] Total number of plants in 4 replications of each treatment; number of infected plants at date of initial and final count. The initial count of infected plants at each location indicates incidence of wilt at time of application of antibiotics.

[c] Percentage increase indicates total increase in number of infected plants from initial to final count in relation to the total number of plants per treatment in the three tests combined.

fected for the entire season or succumbed. The incidence of wilt increased in all plots during the interval from the initial to the final count of infected plants (Table 2). However, at each location, the increase in number of infected plants was greater in the untreated plots than in plots sprayed with streptomycin. In the three tests combined, the total increase in number of infected plants from initial to final count in relation to the total number of plants per treatment averaged 7 to 11 percent in the treated plots and 19 percent in the untreated (Table 2). The differences between streptomycin treatments were not significant. The streptomycin sprays were nonphytotoxic to corn seedlings. Healthy plants sprayed with streptomycin produced normal ears.

DISCUSSION

Some of the plants included in the increase in number of infected plants undoubtedly were infected but had not developed wilt symptoms prior to the application of the streptomycin sprays. The majority of the other plants contributing to the increase in number of infected plants must have been inoculated with the wilt bacterium in the course of the feeding activities of the flea beetles during the 10- to 12-hour period of daylight from the time of the application of the streptomycin sprays to the first application of DDT.

The eradication of incipient infections by streptomycin absorbed from the leaf surfaces and translocated to the site of infection may have contributed to the lower incidence of wilt-infected plants in the treated plots than in the untreated. However, the amount of streptomycin supplied by the one or two sprays applied in these tests seems hardly sufficient to provide for the systemic distribution of the antibiotic within the plants at an effective antibacterial concentration. The lack of any apparent therapeutic effects lends support to this hypothesis.

The lower incidence of wilt-infected corn plants in the plots sprayed with streptomycin than in the unsprayed plots appears to have resulted from inactivation of the wilt bacteria before infections became established. Some of the reduction in incidence of wilt in the treated plots may be attributed to the inactivation of bacteria in flea beetle lesions exposed to the streptomycin sprays before infections were initiated. Control provided in this manner would be restricted to the inactivation of only those bacteria which were recently introduced into the flea beetle lesions and which were directly exposed to the antibiotic sprays. The lower incidence of wilt-infected plants in the sprayed plots than in the unsprayed may also be attributed to the inactivation of bacteria on the mouth parts of the beetles, and to inactivation of bacteria within the body of the beetles by streptomycin ingested along with epidermal tissues during the feeding activities of the beetles on foliage sprayed with streptomycin.

Frequent applications or higher concentration of streptomycin than that used in these exploratory tests may have exerted therapeutic activity and provided for the effective control of the spread of the wilt bacteria. The absorption and translocation of streptomycin applied as a spray to the foliage of corn should be investigated. The distribution of absorbed antibiotics in corn plants may differ considerably from that described in bean plants (9) since the more or less parallel arrangement of veins in monocotyledonous plants may result in a pattern of distribution of absorbed materials that differs considerably from that resulting from the anastomosing type of vascular system characteristic of dicotyledonous plants. Other antibiotics may be more effective than streptomycin against Bacterium stewartii. Aureomycin and Terramycin have been reported more effective than streptomycin against phytopathogenic bacteria (6). Although the differences between incidence of wilt-infected plants in plots treated with streptomycin and in untreated plots were not sufficient to justify any statements as to the value of this method of control of Stewart's wilt of corn, the results were sufficiently encouraging to warrant further investigations on its control by antibiotic sprays.

Literature Cited

1. Beach, W. S., and H. B. Engle. 1955. Tobacco wildfire control by streptomycin nitrate. Plant Dis. Reptr. 39: 15-16.
2. Conover, R. A. 1954. Control of bacterial spot of tomato and pepper seedlings with Agrimycin. Plant Dis. Reptr. 38: 405-409.
3. Dunegan, J. C., J. R. Kienholz, R. A. Wilson and W. T. Morris. 1954. Control of pear blight by a streptomycin-Terramycin mixture. Plant Dis. Reptr. 38: 666-669.
4. Goodman, R. N. 1954. Fireblight control with sprays of Agrimycin, a streptomycin-Terramycin combination. Plant Dis. Reptr. 38: 874-878.

5. Heggested, H. E., and E. E. Clayton. 1954. Control of tobacco wildfire with streptomycin sulfate. Plant Dis. Reptr. 38: 661-665.
6. Katznelson, H. and M. D. Sutton. 1951. Inhibition of plant pathogenic bacteria in vitro by antibiotics and quaternary ammonium compounds. Canad. Jour. Bot. 29: 270-278.
7. Kirby, R. S. 1954. Effectiveness of antibiotics for apple fire blight control under epidemic conditions in Pennsylvania. Plant Dis. Reptr. 38: 432-433.
8. _____. 1955. Control of tobacco wildfire with streptomycin preparations. Plant Dis. Reptr. 39: 14.
9. Mitchell, J. W., W. J. Zaumeyer, and H. Preston, Jr. 1954. Absorption and translocation of streptomycin by bean plants and its effect on the halo and common blight organisms. Phytopath. 44: 25-30.
10. Winter, H. F. and H. C. Young. 1953. Control of fire blight of apples in Ohio in 1953. Plant Dis. Reptr. 37: 463-464.

DEPARTMENT OF PLANT PATHOLOGY, NEW YORK STATE AGRICULTURAL EXPERIMENT STATION, GENEVA, NEW YORK

GALLS SIMILAR TO CROWN GALL AND NEMATODE INJURY PRODUCED BY 2, 4-D[1]

R. D. Watson[2]

INTRODUCTION

Plant specimens with various types of abnormal gall-like growth on the roots had been received for identification and possible recommendation for control measures. The galls were suggestive of nematode injury on beets and carrots and crown gall on cabbage. Except for reduced size of the plants, there were no above-ground symptoms.

Since none of the gall forming nematodes or other pathogens usually associated with these types of abnormal growth were obtained in repeated isolations, the possibility that the gall-like structures were the result of a growth hormone was considered. Carlyle and Thorpe[3] and Anderson and Baker[4] applied 2,4-D to the soil and obtained unusual plant growths. They describe various abnormal twisting and binding of roots and stem and reduced growth, but no gall formation.

Field experiments were conducted by Seely[5] in 1946 and 1947 at the University of Idaho on the possible use of 2, 4-D in vegetable production both in pre-emergence and post-emergence applications at rates ranging from approximately 2 ounces to 6 pounds per acre. These tests demonstrated the marked differences which occur from 2, 4-D in the soil and 2, 4-D applied to the foliage. Malformed and calloused roots with excessive small root production were common on carrots and beets from soil applications whereas these were usually absent from foliage treatments.

Further investigation showed that the practice of spraying ditch banks with 2, 4-D had been fairly common in certain sections of Idaho. This suggested that the damage observed may not have resulted from 2, 4-D in the soil, but may have been the result of contaminated irrigation water.

MATERIALS AND METHODS

An Amine form of 2, 4-D was applied to carrots, parsnips, beets, and several members of the cabbage family in greenhouse in the following manner: (1) as a spray on the foliage, (2) as a drench to the soil but avoiding contact with foliage, and (3) mixed with the soil prior to planting seed.

It was applied in the earlier experiments at rates starting at 100 parts per million in which pasteurized greenhouse soil mixtures were used. In later experiments the tests were made with 5 and 10 p.p.m. of irrigation water and were conducted in pasteurized sand. The plants were treated as seedlings, then larger plants, and finally as transplanted mature stecklings.

RESULTS

The most satisfactory method for producing root galls on plants was the drench method, simulating irrigation with contaminated irrigation water. The soil treatment and foliage applications in the greenhouse failed to produce the root galls observed, but soil applications at low rates have produced galls on carrots and beets somewhat similar to those shown here and with no typical top symptoms of the 2, 4-D.

At any stage of their development, the plants developed root galls with the drench method of application. The best concentrations varied somewhat for each individual plant under experiment, but at a concentration of 5 to 10 p.p.m. one to two drenches during the plant's growth

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[1] Published with the approval of the Director as Research Paper No. 385 of the Idaho Agricultural Experiment Station.

[2] Associate plant pathologist, Idaho Agricultural Experiment Station, Moscow, Idaho.

[3] Carlyle, R. E. and John D. Thorpe - "Some Effects of Ammonium and Sodium 2, 4-D Chlorophenoxyacetates on Legumes and the Rhizobium Bacteria." Journal of American Society of Agronomy. 39: 929-936. 1947.

[4] Anderson, Guy R. and G. Orien Baker - "Some Effects of 2, 4-D in Representative Idaho Soils." Journal of American Society of Agronomy. 42: 456-58. 1950.

[5] Seely, C. I. Unpublished data.

FIGURE 1. Beet seedling with numerous galls formed along the tap root.

FIGURE 2. Galls produced on carrot steckling root with two irrigations of 2,4-D.

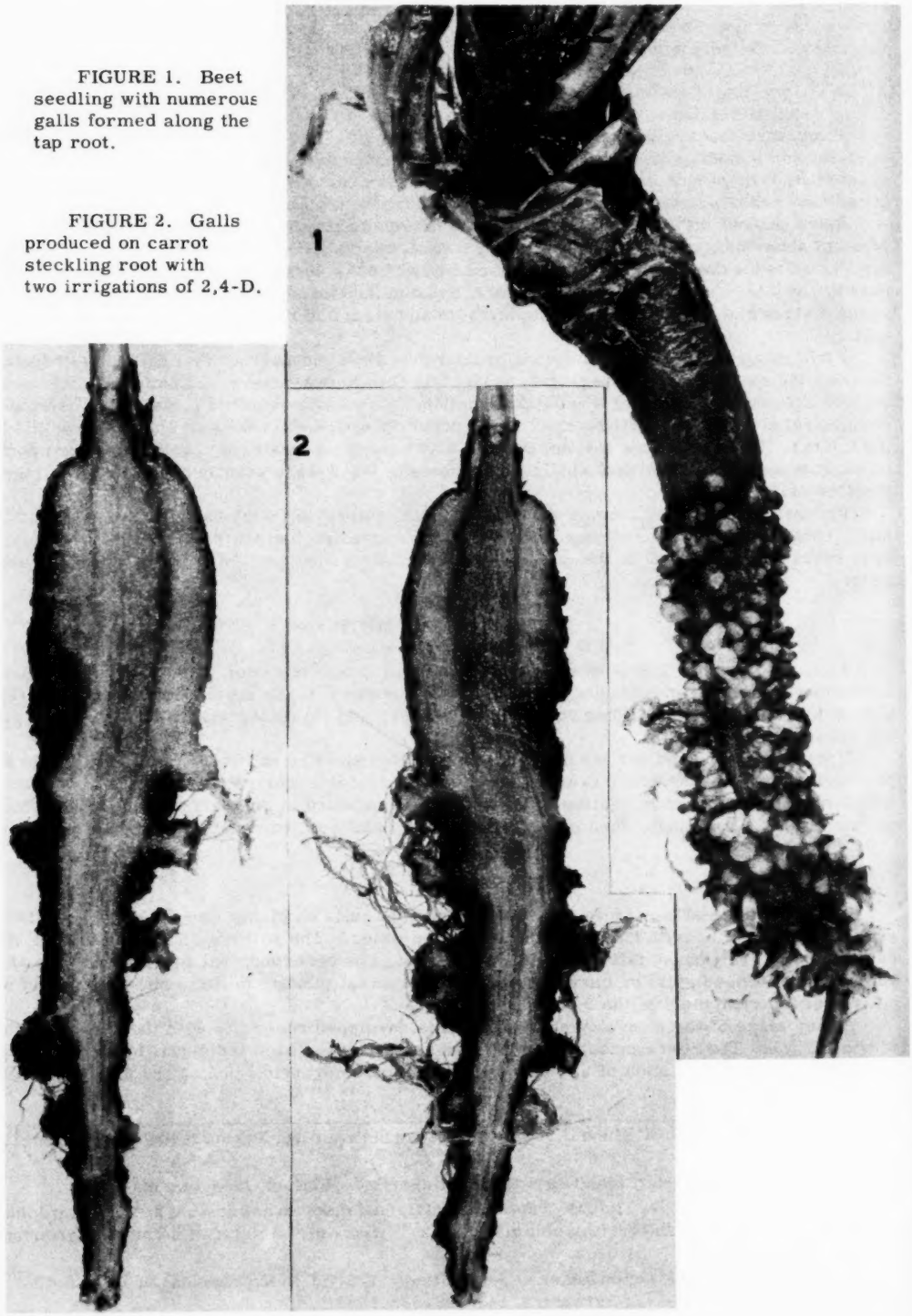
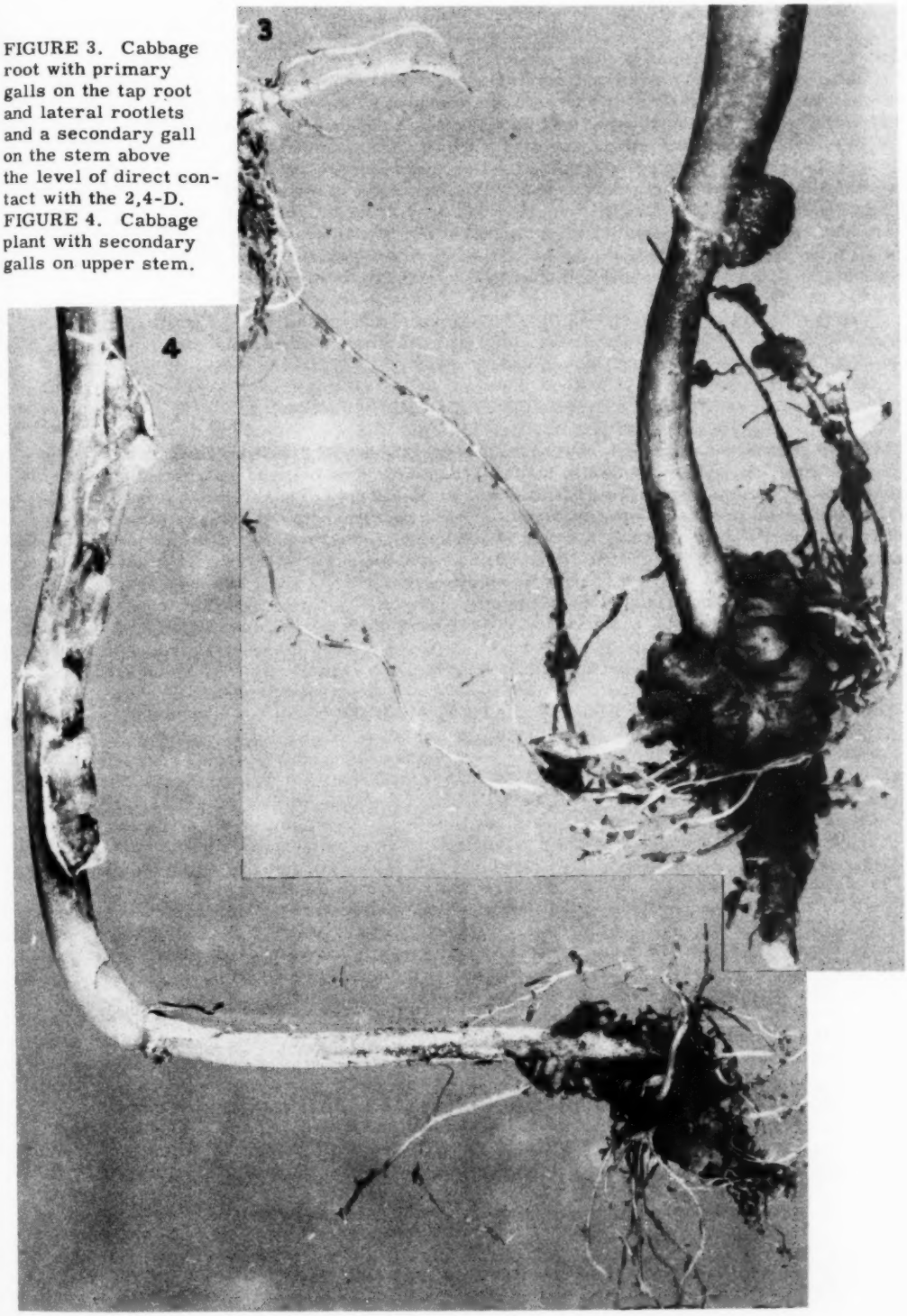


FIGURE 3. Cabbage root with primary galls on the tap root and lateral rootlets and a secondary gall on the stem above the level of direct contact with the 2,4-D.
FIGURE 4. Cabbage plant with secondary galls on upper stem.



produced root galls (Fig. 1, 2, 3 and 4) which were very satisfactory for the purpose of these experiments. Plants producing galls failed to show symptoms typical of 2, 4-D injury to the foliage. Root growth was inhibited, especially at higher concentrations. This often caused the death of seedlings and small plants.

Galls were produced on all of the plants used in these tests and were roughly of three classes: the primary galls of two types were produced by direct contact of 2, 4-D on the roots. These were of the hairy root type, and the local swellings were relatively free from roots. (Fig. 1, 2, 3, and 4).

In a few plants, notably the cabbage family, there were secondary tumors produced at some distance above the point of contact with 2, 4-D. These galls were suggestive of crown gall in their development (Fig. 3 and 4).

The stage of development of the plant had little effect on whether galls were produced by 2, 4-D in the irrigation water. However, the stage of development was an important factor to be considered since seedlings are much more often killed by lower concentrations than are larger plants.

The most suitable concentration of 2, 4-D for producing galls on plant roots by means of water was five to ten parts per million. Repeated drenches produced more galls and increased their size.

CONCLUSIONS

These galls experimentally produced in the greenhouse by 2, 4-D in the irrigation water were similar to the galls observed in the field from which the original specimens had been taken. This, with the observation that those same fields did not have a recurrence of the abnormal root galls in subsequent plantings, supports the conclusion that the galls, poor growth, and seedling death were probably a result of 2, 4-D which was transmitted to the plants in irrigation water.

IDAHO AGRICULTURAL EXPERIMENT STATION, MOSCOW

PROGRESS REPORT ON STUDIES ON THE REPRODUCTION OF THE BURROWING NEMATODE, RADOPHOLUS SIMILIS (COBB) THORNE, ON CITRUS SEEDLINGS GROWING IN PETRI DISHES

William A. Feder and Julius Feldmesser

The burrowing nematode, Radopholus similis (Cobb) Thorne has been determined (2) to be the cause of "spreading decline," a serious condition affecting citrus trees in Florida. This nematode belongs to the sub-family Pratylenchinae and apparently spends the major portion of its life within the feeder roots of citrus or other host plants. Little is known about the life cycle and biology of this nematode and studies thereon are complicated by the relatively small numbers of R. similis that are usually collected from infected citrus feeder roots. The technique described in their article was developed to permit biologic studies of this nematode to be made in the laboratory with relatively few specimens on a minimum of plant material and under controlled conditions.

Burrowing nematodes were extracted from infected citrus feeder roots, variety Rough lemon, by incubation (3). A water nematode suspension, with reduced numbers of protozoa, bacteria, and fungal spores was obtained by passing the original suspension through a Büchner funnel (1), treating the nematodes on the funnel disc with 0.5% Clorox for 1 minute and rinsing with three changes of sterile distilled water. The nematodes were then washed off the disc into a dish of sterile distilled water[1]. Steam-sterilized petri dishes were charged with 15 ml. of a 1.5% water agar made from Difco Bacto Agar. Water agar was used because its clarity facilitates microscopic observation and its low nutritional level reduces bacterial and fungal contaminants to a minimum. Rough lemon and Duncan grapefruit seedlings, grown from seed with seed coats removed and germinated in glass moist chambers or in Vermiculite-filled flats, were used in these studies. Disease-free seedlings with uninjured radicles 2-3 cms in length were placed singly or in pairs on the agar in the petri dishes, with the growing point of the radicle gently pressed into the agar. Duncan grapefruit was used in the first series in which individuals and pairs of immature female burrowing nematodes were placed on the agar against the radicle tip with a finely drawn glass pipette flamed in alcohol. Care was taken not to injure the root tip with the sharp pipette. Controls were run with nematode-free water from the water-nematode suspension. All dishes were covered and incubated in moist chambers in the laboratory. Temperatures during the period in which these studies were made ranged from a minimum of 70° to a maximum of 95° F.

The citrus seedling grows so slowly that even after a month it does not grow beyond the confines of a petri dish. Periodic observations were made for about 30 days; after 15 to 20 days, individual lesions appeared on the grapefruit radicles. The abnormal areas were cut out of the grapefruit roots 30 days after inoculation and placed in water in dishes for examination (Fig. 1). The lesions were sharply defined, raised, corky, and brown. The cortex was split longitudinally to the depth of the stele and the walls of this cavity were heavily callused. The lesions were distinct and entirely separated on the individual roots. Large numbers of burrowing nematodes in all stages of development were teased from these lesions. Control roots inoculated with nematode-free water showed occasional superficial brown areas, but no nematodes were recovered from them.

Immature females recovered from these grapefruit roots were inoculated into Rough lemon roots by the technique described previously. After 15 to 20 days yellow-brown decay areas appeared on the Rough lemon radicles. These decay areas were softer than the surrounding tissues and the lesions were more diffuse than those on the grapefruit. There was very little raising or roughening of the lesion area and the cortical tissues were not split. Large numbers of burrowing nematodes were teased from these lesions. These nematodes have since been inoculated into grapefruit roots, but results are not yet available. This work is being continued.

These results indicate that seedling citrus roots of Rough lemon and Duncan grapefruit grown on water agar in petri dishes in the laboratory can be inoculated with the burrowing nematode, R. similis. The nematode completes its life cycle in these roots under these conditions and the progress of the infections can be followed under the microscope. The nematodes that have developed in vivo are capable of infecting new citrus roots under identical conditions. The role of contaminating organisms associated with these nematodes is not understood at present.

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[1] Various recovery techniques other than the two used here may be employed in securing cleaned nematode inocula. These include the Baermann funnel, nested sieve series, etc.

FIGURE 1. Lesion on Duncan grapefruit root grown in vitro, 30 days after inoculation with the burrowing nematode, Radopholus similis.

This technique should facilitate studies on the biology of the burrowing nematode.

Literature Cited

1. Feder, William A., and Julius Feldmesser. 1954. The Büchner funnel as an aid in collecting and concentrating nematode populations. Plant Dis. Reptr. 38: 805-806.
2. Suit, R. F., and E. P. DuCharme. 1953. The burrowing nematode and other parasitic nematodes in relation to spreading decline of citrus. Plant Dis. Reptr. 37: 379.
3. Young, T. W. 1954. An incubation method for collecting migratory endo-parasitic nematodes. Plant Dis. Reptr. 38: 794-795.

FRUIT AND NUT CROPS SECTION, ORLANDO, FLORIDA, AND NEMATOLOGY SECTION, SANFORD, FLORIDA, HORTICULTURAL CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

RESULTS OF LABORATORY EXPERIMENTS WITH HIGH-VOLTAGE, NON-THERMAL ELECTRICAL TREATMENTS FOR CONTROL OF ROOT-KNOT NEMATODES

Bert Lear and F. C. Jacob

Introduction

A report from Southern Rhodesia by Daulton and Stokes (1952)[1] of success with electrical treatments for control of root-knot nematodes in laboratory and field prompted additional work in this subject here and in Hawaii. Electrical equipment duplicated as nearly as possible from the descriptions of Daulton and Stokes was utilized at the Cotton Experiment Station at Shafter[2] and by the Pineapple Growers Association in Hawaii[2] with no success. As a result, a detailed study was begun in the laboratory at Davis with equipment which could be controlled accurately and the treatments easily duplicated.

Electrical Equipment

The source of electrical energy was a half-wave voltage-doubling rectifier fed by a neon sign transformer. A variable auto-transformer on the primary side permitted choice of output voltage. (See schematic diagram).

A very high momentary energy release through the soil samples was obtained by sudden discharge of a capacitor charged to the output voltage of the rectifier. This method is readily reproducible. Besides the convenience offered as an electrical storage device, the capacitor facilitates quantitative electrical determination of the energy going into the treatment. A spark gap was used as switch to discharge the capacitor through the soil sample. A resistance in series with the rectifier and capacitor plus the internal resistance of the power supply quenched the spark after each discharge. The energy dissipated in the spark was small compared to that dissipated in the soil.

Treatments

The infested soil used in these two experiments was a sandy loam with a moisture equivalent of 12 percent. It was obtained from a metal greenhouse tank in which tomato plants heavily infected with root-knot nematode, Meloidogyne incognita var. acrita, had been growing for several months. Nematodes present in the soil were mainly second stage larvae although some eggs also were present. Enough soil was provided for the two experiments so that after the experiment with wet soil (11.0 percent) was conducted, the remainder was dried (5.9 percent) for the second experiment. The soil samples were placed in a rectangular plastic box between copper plates 1 1/4 inches apart. Each plate surface was 2.2 x 2.25 inches and the treated volume of soil was about 6.2 cubic inches. As the soil was tamped lightly into the box an effort was made to obtain uniform density.

The temperature of the soil samples was measured before and after treatments. Before treatment the d.c. electrical resistance for each sample was measured. These measurements together with the weight of each sample provide a basis for estimating the uniformity of samples and treatments.

The breakdown voltage for wet soil (11.0 percent) between electrodes spaced 1.25 inches apart was about 13 kilovolts -- higher for dry soil. A value of 12 kilovolts was chosen as the maximum voltage for treatments. Up to 10 discharges from a 1 microfarad capacitor or 300 discharges from a 0.035 microfarad capacitor were delivered in 1 minute or less to infested soil. The maximum treatments produced a temperature rise of 25° F. for the wet soil, and 21° F. for the dry soil. Initial soil temperature was about 50° F. so that lethal temperatures were not reached.

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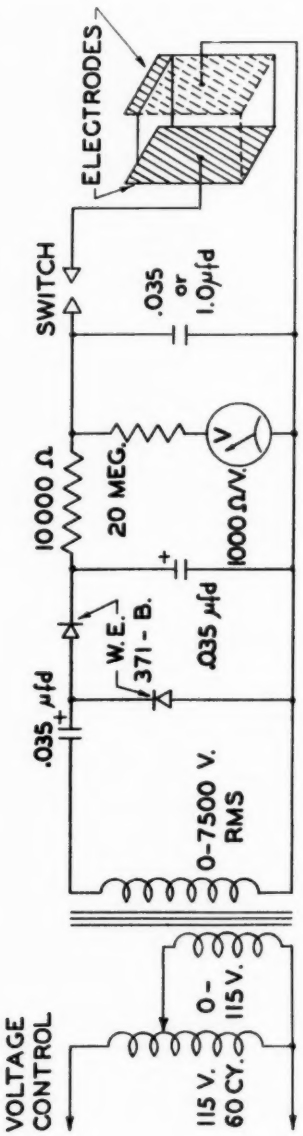
[1] Daulton, R. A. C., and W. M. Stokes. 1952. Empire Journal of Exper. Agric. 20: 271-273.

[2] Unpublished work.



SCHEMATIC DIAGRAM OF POWER SUPPLY FOR NEMATODE TREATMENTS

FIGURE 1.

Evaluation of Treatments

Immediately following treatment, soil samples were transferred to individual clean 4-inch clay pots along with enough nematode-free soil to fill the pot. A tomato seedling was transplanted from clean soil to each pot. After 5 weeks the roots of the tomato plants were washed free of soil and the number of root-knot nematode galls present in the roots were recorded (Table 1).

Table 1. Gall counts from tomato plants grown in root-knot nematode infested soils exposed to various high voltage, non-thermal electric treatments.

	Treatment				Mean number galls per plant	
	Peak Kilovolts	Charge Repetitions	Capacitor mfd.	Energy watt-sec.	Wet soil*	Dry Soil**
1.	Check - no treatment				156	244
2.	12	300	0.035	755	150	151
3.	12	30	0.035	76	180	225
4.	8	300	0.035	336	133	195
5.	8	30	0.035	34	160	190
6.	12	10	1.0	720	144	174
7.	12	1	1.0	72	141	158
8.	8	10	1.0	320	167	175
9.	8	1	1.0	32	136	202
10.	11	10	1.0	605	142	-
11.	11	1	1.0	60	123	-

*Soil moisture 11.0% - Mean size sample treated 116 grams.
**Soil moisture 5.9% - Mean size sample treated 123 grams.

Treatments 2 and 6 were the most severe since for them the maximum voltage was used and the energy dissipated in the soil was larger than for the others. Calculation shows that to administer this in the field, treating a swath 6 feet wide and 2 feet deep, moving at 2 miles per hour, would require a generator of more than 10,000 horsepower capacity.

From this limited study it appears that high-voltage, non-thermal electrical soil treatments are impractical. In these tests a maximum feasible treatment, limited in severity by voltage breakdown of the soil and by temperature rise from the dissipated electrical energy, produced no discernible reduction in number of nematodes surviving in the treated samples. Since these results were obtained from a very small sample of infested soil, it is difficult to see how similar treatments succeeded in field treatments as reported from Southern Rhodesia.

DEPARTMENT OF PLANT NEMATOLOGY AND DEPARTMENT OF AGRICULTURAL ENGINEERING, UNIVERSITY OF CALIFORNIA, DAVIS, CALIFORNIA

A RESIDUAL ORGANOPHOSPHORUS NEMATOCIDE

M. A. Manzelli

Abstract

Field work initiated in 1953 and continued through 1954 has shown that O-2, 4-dichlorophenyl O, O-diethyl phosphorothioate is capable of controlling parasitic nematodes attacking turf and lawn grasses. Applied as a drench or spray, or injected into the soil at rates of 125, 250 and 500 pounds of technical grade material per acre, it has succeeded in reducing the populations of the pathogenic nematodes sufficiently to permit the grasses to regain their former vigor and growth.

It is generally agreed among researchers in the field of nematocides that the ideal nematocide should possess at least the following two characteristics. First, it should be toxic to a wide range of nematode species which inhabit a wide range of soil types; and secondly, it should be non-phytotoxic. Other characteristics, such as toxicity to weeds, weed seeds and fungi are also desirable, but not necessary for a material to be a successful nematocide (3).

The present-day proprietary nematocides are soil fumigants which, while toxic to most nematodes, are also phytotoxic to most plant growth. Some of these fumigants have been employed at reduced dosages on living plants but the control achieved has not been satisfactory.

Nematodes may be distributed from the surface of the soil to a reported depth of over 6 feet. Therefore, adequate volatility and water solubility are characteristics which have been deemed necessary in order that a soil fumigant may disperse and make contact with the relatively immobile nematodes. Fumigants which possess these characteristics are known generally as non-residual nematocides. Their effectiveness is dispersed rapidly (1).

A residual nematocide implies that the material is relatively non-volatile and that the area of its dispersion pattern is small. Some difficulty would be expected in effectively applying such a material to any great depth. Within limits, this implication is true, but there are favorable combinations of soil type and plant growth which permit the successful, facile use of a relatively non-volatile, residual nematocide.

One example of such a condition exists in nematode infested golf greens and lawns. The nematodes attacking these grasses, because of their close proximity to the surface, are quite susceptible to control with non-volatile, residual-type nematocides applied as sprays or drenches. The residual property of the employed nematocide is effective in preventing the nematodes from quickly reinfesting the root zone of the grasses, as would occur if a highly volatile, non-residual nematocide were used.

A residual, relatively non-volatile and non-phytotoxic nematocide, V-C 13[1], has been under greenhouse and field study since 1952. Its activity was first reported by nematologists of the USDA Central Florida Experiment Station, Sanford, Florida, who were cooperating in the Chemical-Biological Coordination Center evaluation program. The active ingredient in V-C 13 is O-2, 4-dichlorophenyl O, O-diethyl phosphorothioate. The technical grade material is a dark, straw-colored liquid, which has a boiling point of 124°-130° C at 0.25 mm of Hg. It is insoluble in water, but is readily soluble in most organic solvents.

In the field V-C 13 has been evaluated for the control of nematodes detrimental to the growth of a wide variety of truck crops, fruit trees, ornamentals and grasses. This report will present only the work conducted with V-C 13 for the control of nematodes which attack grasses on golf greens and lawns.

V-C 13 has been formulated as a 75% emulsifiable concentrate, and has been employed experimentally at dosage rates equivalent to 125, 250 and 500 pounds of technical grade material per acre. The recommended dosages for field use range from 125 to 250 pounds per acre.

In usage, the concentrate has been diluted to the proper strength with water and has been applied to grasses by one of the following methods: power sprayers, hose aspirators, watering cans and soil injectors. The usual procedure for treating grasses by the spray or drench method has consisted of prewatering the dry turf, applying V-C 13 emulsion, and again watering the turf in order to flush off onto the soil surface any V-C 13 emulsion that may have re-

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[1] A product of the Virginia-Carolina Chemical Corporation, Richmond, Virginia, registered as "V-C Nemacide" a 75% Emulsifiable Concentrate.

mained on the grass blades.

The injection method of applying V-C 13 has been employed with good results. Hand-operated injectors, each equipped with a pointed, perforated tip, easily penetrated the soil to permit delivery at the desired depth. However, this means of application was both time-consuming and tedious, even though it did deliver the nematocide to the infestation zone in a more direct manner than did the spray or drench method.

The spray or drench method was preferable to all other methods employed. The amount of toxicant used was based on the square footage of the surface area to be treated. The necessary amount of V-C 13 was diluted with sufficient water to insure the complete wetting of the specified area. Generally, the application was carried out with equipment already on hand, as for example, power sprayers, hose aspirators and watering cans.

During the year 1954, following the initial field evaluation of V-C 13 in 1953, extensive test plots were established in Florida on golf greens. The grasses exposed to treatments included St. Augustine, annual rye, Bermuda, Gene Tift, and Everglades No. 1. These latter two are improved strains of Bermuda.

The nematode populations found associated with the grasses was quite large, and included the following plant pathogenic species:

Aphlenchoides sp.	
Dorylaimus spp.	Spear nematodes
Hoplolaimus spp.	Lance nematodes
Paratylenchus spp.	Pin nematodes
Pratylenchus spp.	Meadow nematodes
Rotylenchus spp.	Spiral nematodes
Trichodorus spp.	Stubby-root nematodes
Tylenchorhynchus spp.	Stylet nematodes

With one exception, only single spray or drench applications of V-C 13 were made to the test turfs. The test plots were initiated in the months of February, May, August, September, October and November.

The period of time required for evidence of improvement in the treated turf was shown to be correlated with the following factors: the time of year the application was made; the dosage employed; the soil-type involved; and the variety of grass being treated. When the nematocide application was made during the warmer months (May, August and September) to turf established on sandy loam soil, 3 to 4 weeks would elapse before improvement was clearly demonstrable, whereas a 5- 6- week period was required when application was made during the cooler months (February, October and November) to the same soil type.

A portion of a heavily infested turf, established on muck soil and treated during August, did not show any marked improvement until 8 to 9 weeks had elapsed, at which time the treated section contrasted markedly with the untreated area. It is thought that the movement of V-C 13 in heavy soils is retarded, and this in turn extends the period of time required for the nematocide to control the attacking nematodes.

In general, the appearance of a badly infested green in Florida was characterized by sparse grass growth and by a distinct fading or yellowing of the grass blades. This was brought about by the reduction or almost complete destruction of the grass roots, a condition not necessarily caused wholly by nematodes, but partially with the aid of secondary invading organisms (2). The visual evidence of nematode control by V-C 13 on such infested turf was very marked. In the majority of the green tests, a section of turf was left as an untreated check. By this method, a differential, visual reading could be made quickly of the untreated and the treated areas. On the treated section, the reduction of nematodes was followed by the re-establishment of grass roots, and this condition was reflected in the improved coloration, growth and density of the grass. A core of the turf was taken by means of a grass plugger or soil sampler and demonstrated a greatly improved root system.

In addition to the visual data, nematode population counts were made prior to and following treatment. Untreated plots were also sampled at such times for a determination of their nematode population. In the majority of cases, the population counts made shortly after treatment indicated reductions in both number and species of nematodes.

In some instances, some slight phytotoxicity to the grass blades was noted when V-C 13 was applied at either the 250 or 500 pounds per acre basis by the spray or drench method. The injury was characterized by the browning of the grass blade tip, a condition which usually lasted

Table 1. Effect of V-C 13[a] treatment on greens infested with nematodes.

Plot No.	V-C 13 Per acre	Relative nematode population	Soil type	Grass type	Green condition	Control achieved: Relative nematode population[b]	Control achieved: Green condition
1	125 lbs	Heavy	Sand-Muck	Bermuda-Improved Strain	Grass sparse and yellow. Root system poor.	Light	Greatly improved blade and root systems.
	Untreated Check	Heavy	Sand-Muck	Bermuda-Improved Strain	Grass sparse and yellow. Root system poor.	Heavy	Blade and root systems very poor.
2	125 lbs	Light	Sand-Loam	Bermuda	Grass growth generally good, few bare spots.	Light	Grass condition good.
	Untreated Check	Light	Sand-Loam	Bermuda	Grass growth generally good, few bare spots.	Light	Grass condition good.
3	250 lbs	Light	Sand-Loam	Bermuda-Tift Strain	Grass sparse and yellow. Root system poor.	None	Greatly improved blade and root systems.
	Untreated Check	Light	Sand-Loam	Bermuda-Tift Strain	Grass sparse and yellow. Root system poor.	Light	Grass sparse and yellow. Root systems poor.
4	250 lbs	Heavy	Sand-Muck	Bermuda-Tift Strain	Grass sparse and yellow. Root system poor.	None	Greatly improved blade and root systems.
	Untreated Check	Heavy	Sand-Muck	Bermuda-Tift Strain	Grass sparse and yellow. Root system poor.	Light	Grass sparse and yellow. Root systems poor.

Table 1. (Continued).

Table 1. (Continued).

Plot No.	V-C 13 Per acre	Relative nematode population	Soil type	Grass type	Green condition	Control achieved: Relative nematode popluation[b]	Control achieved: Green condition
5	250 lbs	Light	Sand-Loam-Marl	Bermuda	Grass growth generally good - but yellow.	None	Grass growth good.
	Untreated Check	Light	Sand-Loam-Marl	Bermuda	Grass growth generally good - but yellow.	Light	Grass growth good.
6	250 lbs	Moderate	Sand-Loam	Bermuda-Everglades No. 1 Strain	Grass extremely sparse and yellow. Root systems poor.	None	Greatly improved blade and root systems.
7	250 lbs	Heavy	Sand-Muck	Bermuda	Grass extremely sparse and yellow. Root systems poor.	Moderate	Greatly improved blade and root systems.
	Untreated Check	Heavy	Sand-Muck	Bermuda	Grass extremely sparse and yellow. Root systems poor.	Heavy	Grass extremely sparse and yellow - root systems poor.
8	500 lbs	Heavy	Sand-Loam	Bermuda	Grass extremely sparse and yellow. Root systems poor.	None	Greatly improved blade and root systems.
	Untreated Check	Heavy	Sand-Loam	Bermuda	Grass extremely sparse and yellow. Root system poor.	Light	Grass extremely sparse and yellow - root systems poor.

[a] A product of the Virginia-Carolina Chemical Corporation, Richmond, Virginia, registered as "V-C 13 Nemacide", a 75% Emulsifiable Concentrate.

[b] Counts made two months after treatment.

from 1 to 2 weeks before disappearing. The grass roots were not injured in any of the tests, as demonstrated by the new root growth that followed treatment.

The duration of the residual life of V-C 13 in turf soil is as yet unknown, but it has been shown to be in excess of 7 months at the 250 pounds per acre application in sandy loam soil. Undoubtedly the residual life span will be influenced by the soil type, soil temperature range, method of application and treatment level.

Table 1 lists the results obtained from some of the Florida test plots during 1954.

From a study of Table 1, it can be seen that where the relative nematode population or infestation of a turf was light, at times treatment with V-C 13 did not bring about any marked change in the turf condition. The most striking improvements in the greens occurred in those plots which had initially shown a very high relative nematode population and very poor turf growth.

In one instance, where the nematode destruction was so complete as to destroy the Bermuda grass, treatment with V-C 13 of a section of the green permitted the establishment of a heavy growth of weed grass. The untreated remainder of the green was bare of any type of grass growth whatsoever.

Tests similar to those reported above have been conducted with V-C 13 in the eastern section of the United States at both the 250 and 500 pounds per acre rates. Very good control of the nematodes was obtained, and the grass response was excellent, although the 500 pounds per acre treatment caused slight, temporary injury to the grass blades. A heavy soil type was involved, and the time necessary for demonstrating grass response was somewhat longer in these instances than in the light-soil-type tests conducted in Florida.

Literature Cited

1. Chitwood, B. G. 1952. Nematocidal action of halogenated hydrocarbons. Agricultural Applications of Petroleum Products, Advances in Chemistry Series No. 7: 91-99.
2. Graham, T. W. 1954. Plant abnormalities caused by parasitic nematodes. Plant Dis. Reptr. Suppl. 227: 83-84.
3. McBeth, C. W. 1954. Some practical aspects of soil fumigation. Plant Dis. Reptr. Suppl. 227: 95-101.

VIRGINIA-CAROLINA CHEMICAL CORPORATION, RICHMOND, VIRGINIA

USE OF ANTI-FERMENTATIVE CHEMICALS FOR MAINTAINING CULTURES OF PANAGRELLUS REDIVIVUS FOR NEMATOCIDE SCREENING[1]

Pen Ching Cheo and A. C. Tarjan

Panagrellus redivivus (Linn. 1767) Goodey 1945, has been used extensively by this laboratory as an organism for contact nematocide tests[2]. This nematode is easily cultured at room temperatures on cooked oat meal medium[3] contained in petri dishes. Due to the gas-forming action of coexisting fermentative organisms, however, the medium bubbles up and creates a seal around the covered dish, shutting off the oxygen supply. Under such anaerobic conditions, nematodes in the medium usually succumb. Sometimes the fermentation process progresses so rapidly that the medium becomes excessively acid and stops further nematode multiplication. It was the purpose of this study to discover chemicals that could be incorporated in the medium in order to inhibit excess fermentation without injuriously affecting nematode multiplication.

The basic medium consisted of 1 part by weight of oat meal to 9 parts of water. For test purposes, 3 ml of a stock solution of each chemical was mixed with 27 ml of the cooked oat meal in a petri dish so that the desired concentration in ppm was obtained. A standard aliquot of nematode inoculum from an established culture was introduced into the contents of each dish prior to incubation at room temperatures varying from 16° to 28°C.

The following chemicals at concentrations of 10, 50 and 100 ppm were included in these tests: oxyquinoline benzoate, mercuric chloride, Calco R3876-20[4], copper sulfate, sulfanilimide, lactic acid, carbolic acid, tetrachloro-p-benzoquinone (chloranil), boric acid, aureomycin, Terramycin, crystal violet, sodium fluoride, sodium cyanide, citric acid, and sodium thiosulfate. Also used were iodoacetic acid (at 1, 5, 10, 25, 50, and 100 ppm), zinc oxide (at 1, 5, 10, 50, 100, 250, and 500 ppm), sodium benzoate (at 10, 50, 100, 250, and 500 ppm), Amberlites IRA-400 and IR-120[5] (at 1000, 5000, 10,000, 20,000, 40,000, and 80,000 ppm).

These tests indicated that some chemicals were effective in checking fermentation, but highly toxic to the nematode, i.e., crystal violet, mercuric chloride, sodium fluoride, and sodium cyanide. Other chemicals, such as lactic acid, aureomycin, and Terramycin, favored the growth of such mold species as Mucor, Aspergillus, and Penicillium, by inhibiting bacterial multiplication. These molds grew so rapidly that nematode multiplication was completely inhibited. Other chemicals were either unfavorable to nematode multiplication, or had little or no effect in checking fermentation.

The following chemicals reduced fermentation considerably without apparent harmful effects on nematode multiplication: oxyquinoline benzoate at 50 to 100 ppm; iodoacetic acid at 5 to 10 ppm; zinc oxide at 250 ppm; sodium benzoate at 250 to 500 ppm; and Amberlite IR-120 at 10,000 to 20,000 ppm.

For further comparison of these promising chemicals, weekly pH readings of the different treatments, as well as weekly counts of the nematode population in each dish, were made. In estimating nematode populations, 1/2 ml of the medium was drawn out and diluted with water to 10, 50, or 100 ml as desired, depending on the abundance of nematodes within each dish. Another 1/2 ml from this dilution was drawn out, and the living nematodes counted under the microscope. The total number of nematodes in the original 30 ml of test medium in each dish was calculated according to the dilution reading. Results are given in Table 1.

While the pH value of cooked oat meal medium prior to inoculation was close to neutral, the pH dropped sharply within 5 days after inoculation, presumably due to microbial activity. The lowest limit of acidity allowing nematode growth in the media was pH 3.4. Upon reaching a minimum acidity level a few days after inoculation, the pH of the media gradually increased until a maximum of 8.5 was reached after which further nematode activity was completely stopped. The pH increased at a much slower rate in the media containing Amberlite IR-120 and oxyquinoline benzoate, thus lengthening the period for favorable growth of nematodes. A

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[1]Contribution No. 856 from the Rhode Island Agricultural Experiment Station

[2]Tarjan, A. C. 1955. Evaluation of various nematodes for use in contact nematocide tests. Proc. Helm. Soc. Wash. (In Press)

[3]Recent tests indicate that uncooked oatmeal serves as well for the nematode culturing medium.

[4]Supplied by Calco Chemical Division, American Cyanamid Company

[5]Marketed by the Rohm and Haas Company, Inc.

great reduction in the gas formation within all treatments as compared to untreated checks was noticed about 3 days after inoculation.

Table 1. Effect of chemicals incorporated in oat meal upon nematode multiplication and the pH of the medium.

Treatments		pH population readings at 5 days	13 days	20 days	28 days	34 days
Oxyquinoline benzoate	pH	3.55	3.6	4.1	4.45	—
100 ppm	popl.	27.6*	12.0	71.4	195.0	1152.6
	pH	3.5	3.4	4.4	6.0	—
50 ppm	popl.	31.8	3.6	852.0	1257.0	9.1
Iodoacetic acid	pH	4.25	4.75	6.8	8.3	—
10 ppm	popl.	12.6	345.0	948.0	30.0	1.2
	pH	4.1	4.5	4.8	6.9	—
5 ppm	popl.	6.6	45.0	75.0	525.0	7.8
Sodium benzoate	pH	3.7	5.5	7.1	8.5	—
500 ppm	popl.	7.2	351.0	630.0	0	0
	pH	3.5	5.1	8.0	8.7	—
250 ppm	popl.	20.4	393.0	12.6	0	0
Zinc oxide	pH	3.65	6.0	6.9	8.4	—
500 ppm	popl.	24.0	9.0	0	0	0
250 ppm	pH	3.5	4.95	7.6	8.3	—
	popl.	27.6	186.0	609.0	6.6	0
Amberlite IR-120 4%	pH	3.95	3.65	4.4	5.2	—
	popl.	13.8	54.0	102.0	199.4	142.8
	pH	4.4	3.75	5.05	6.5	—
2%	popl.	20.4	86.4	543.0	102.6	22.2
	pH	3.75	3.85	6.0	8.0	—
1%	popl.	36.0	360.0	1308.0	252.0	9.0
Amberlite IR-120 Amb. IRA-400	pH	3.5	3.4	4.2	5.9	—
1% 1%	popl.	7.2	33.0	138.6	619.2	11.7
Check	pH	3.5	4.5	6.75	8.55	—
	popl.	27.6	345.2	1300.0	0	0

*Population in thousands

Amberlite IR-120, a cation-exchange resin, performed very well in these tests. It is insoluble in water and all other common solvents and is extremely stable at high temperatures and in strong acid or alkaline solutions. It has no direct injurious effects on nematodes, even when incorporated in the medium at a concentration of 8 percent by weight. Nematodes from IR-120-treated cultures were indistinguishable from nematodes obtained from nontreated cultures, on the basis of susceptibility to various nematocides.

DEPARTMENT OF PLANT PATHOLOGY-ENTOMOLOGY, AGRICULTURAL EXPERIMENT STATION, KINGSTON, RHODE ISLAND

GOLDEN NEMATODE AND OTHER POTATO DISEASES IN BOLIVIA[1]

Frank H. Bell and Segundo Alandia B.

During the past 3 years, observations have been made on the diseases of potatoes in Bolivia that should be of interest to pathologists elsewhere, especially since the area may be one of the ancestral homes of the potato.

One of the more interesting organisms noted for the first time in Bolivia is the golden nematode, Heterodera rostochiensis. It was found to be widespread in the Lake Titicaca region of northwestern Bolivia, at an altitude of 12,600 to 13,000 feet. One of the sites where it was noted was on the famous "Island of the Sun" of the prehistoric Incas. It was also found in the Tunari range (altitude 11,000 feet) near Cochabamba. This latter site is 200 miles southwest of Lake Titicaca in mountains that are separated from the main Bolivian Altiplano. The widespread occurrence of this nematode in long cultivated, heavily populated regions of Bolivia substantiates the theory (3) of Ing. de Segura of Peru, where the nematode was also recently noted for the first time, that this nematode is indigenous to the Andes, and was probably carried from there to Europe and then to the United States. The root-knot nematode, Meloidogyne sp., has been found on potato in the sandy soils of the "Island of the Sun", and in the highlands east of the Cochabamba Valley.

Another interesting new record for Bolivia is Thecaphora solani, a smut in which brown specks, or masses of sporeballs, are scattered throughout the flesh of the tuber. This is apparently a rare disease that is found only in the Andes Mountains (1). It has been collected in two localities in Bolivia, both in the upper Cochabamba Valley, locally known as the Cliza Valley, at an altitude of about 9,250 feet.

Wart (Synchytrium endobioticum) and powdery scab (Spongospora subterranea) are both widely distributed in the highlands, being especially common in the high, cool Altiplano near Lake Titicaca, where considerable damage may result from the diseases.

Rhizoctonia solani is also widespread, and is much more common in the lower (9,000 to 11,000 feet) warmer Cochabamba area than the two last diseases.

Late blight (Phytophthora infestans) was severe during the 1953-54 season in certain areas where high moisture conditions prevailed, being most severe on the eastern side of the Eastern Cordillera, where moist winds pour up from the Amazon Valley lowlands. In one such valley near Cochabamba, where the above mentioned conditions result in nearly daily mist, foliage was completely destroyed in early season (January). Only about 10 miles up the valley, however, where the fog rises, blight did not even arrive until after the lower plantings were destroyed. A thorough search in March 1954 for late blight in the heavily farmed Altiplano of the Lake Titicaca region did not reveal any late blight. Since Bolivian technicians at the Altiplano Experiment Station of the Servicio Agricola Interamericano do not definitely know of late blight there, it may be that temperatures are too cold for any appreciable amount of the disease. "Summer" daily minimums at the Experiment Station (altitude 12,600 feet) average about 37°F. It is interesting to note that late blight was first definitely known to occur in Bolivia in 1943 (2).

Early blight (Alternaria solani) has been noted, but is not apparently of economic importance.

Sclerotinia sclerotiorum has been collected in a high valley near Cochabamba.

Virus diseases are common, especially at the lower altitudes of the mountain valleys. In these areas it is a standard custom to bring seed from the highlands, as continued use of local seed results in "run-down" plants.

No identification work has been done on the viruses, although plants with symptoms of leaf roll, rugose mosiac, a calico or aucuba type, etc., are present.

Literature Cited:

1. Barrus, M. F. 1944. A Thecaphora smut on potatoes. Phytopath. 34: 712-714.
2. Cárdenas, Martin. 1943. Origen de la Phytophthora infestans. Revista de Agricultura (of the Universidad Autonoma de Cochabamba) 1: 34.

[1]A contribution from the Servicio Agricola Interamericano, an agricultural service organization operated jointly by the Foreign Operations Administration of the United States Government, the Institute of Inter-American Affairs, and the Bolivian Government.

3. Segura, Consuelo Bazán de. 1952. The golden nematode in Peru. Plant Dis. Reptr. 36: 253.

SERVICIO AGRÍCOLA INTERAMERICANO, ESTACIÓN EXPERIMENTAL AGRÍCOLA, COCHABAMBA, BOLIVIA.

THE EFFECT OF CERTAIN POST STORAGE TREATMENTS ON SOFT ROT DEVELOPMENT IN SWEETPOTATOES[1]

Robert Aycock[2]

SUMMARY

Dipping sweetpotato roots in borax solutions of 1 percent and 2.5 percent concentration effectively reduced soft rot when they were taken from storage and repacked. Recuring for 48 hours at 85°F with relative humidity 60 percent or above appeared to be as effective as borax treatments.

INTRODUTION

Soft rot caused by species of Rhizopus (3) is a serious disease of improperly cured and handled sweetpotatoes in South Carolina. Even when curing and storage are carried out under

Table 1. The effect of fungicidal dips on soft rot development in repacked sweetpotatoes stored at 50-60°F.

Treatment [a]	Mean percentage showing soft rot		Number roots examined
	Percentage	Angle [b]	
Borax, 2.5%	.8	5.06	196
Borax, 1%, 10 min. soak	1.5	6.95	213
Semesan Bel, 1#/7½ gal. [c]	1.5	6.95	209
Borax, 1%	2.5	9.11	203
Vancide 51, 1-1000 [d]	6.7	15.02	209
Seedox, 2#/100 gal. [e]	16.3	23.79	215
Washed, no fungicide	15.0	28.31	214
Unwashed	14.9	22.75	219
LSD (.05)	--	7.80	--
LSD (.01)	--	10.50	--

[a] All treatments were instant dips unless otherwise noted.

[b] Percentages were transformed to angles (angle=arc $\sin\sqrt{\text{percentage}}$) prior to statistical analysis (6).

[c] 12% hydroxymercurinitrophenol, 3.2% hydroxymercurichlorophenol

[d] 30% sodium salts of dimethyl dithiocarbamic acid and 2 mercaptobenzothiozole

[e] 50% trichlorophenyl acetate

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[2]Formerly Plant Pathologist, Clemson Edisto Experiment Station, Blackville, South Carolina. Present address, Vegetable Research Laboratory, Castle Hayne, North Carolina.

Table 2. The effect of curing treatments on development of soft rot in repacked sweetpotatoes.

Treatment	Percentage roots developing soft rot [a]				Total roots examined
	Mean percentage		Mean angle		
	14 days	21 days	14 days	21 days	
Restored immediately, 45-60°F.	9.2	11.9	17.7	20.2	217
Restored immediately, 50-60°F.	13.6	16.9	21.6	24.3	225
85°F. for 24 hrs., storage, 50-60°F.	5.5	8.1	13.6	16.5	241
85°F. for 48 hrs., storage, 50-60°F.	2.1	2.8	8.3	9.7	242
85°F. for 72 hrs., storage, 50-60°F.	3.1	3.9	10.2	11.4	234
85°F. for 96 hrs., storage, 50-60°F.	1.6	2.0	7.3	8.2	237
LSD (.05)	--	--	5.9	7.1	--
LSD (.01)	--	--	8.0	9.6	--

[a] Percentage data were transformed to angles (angle=arc sin$\sqrt{\text{percentage}}$) prior to analysis of variance (6).

Table 3. The effect of various treatments on development of soft rot in repacked sweetpotatoes subsequently hauled 80 miles and stored at 50-60°F.

Treatment	Mean percentage showing soft rot [a]				Total roots examined
	Mean percentage		Mean angle		
	14 days	21 days	14 days	21 days	
Restored immediately	6.3	7.1	14.5	15.4	189
1% Borax dip - storage	.9	2.5	5.4	9.1	177
1% Borax dip - trucked 80 mi. - storage	5.3	12.4	13.3	20.6	188
Trucked 80 mi. - 1% Borax - storage	6.0	8.4	14.2	16.9	198
Trucked 80 mi. - 85°F, 24 hrs. - storage	6.8	9.2	15.1	17.6	188
Trucked 80 mi. - 85°F, 48 hrs. - storage	4.1	7.1	11.6	15.4	188
Trucked 80 mi. - 85°F, 72 hrs. - storage	2.1	4.2	8.3	11.8	187
Trucked 80 mi. - storage	13.3	20.1	21.4	26.7	197
LSD (.05)	--	--	6.6	7.0	--
LSD (.01)	--	--	8.9	9.6	--

[a] Percentages were transformed to angles (angle=arc sin$\sqrt{\text{percentage}}$) prior to statistical analysis

optimum conditions, heavy losses often occur when roots are removed from storage and are graded and repacked.

Daines (2), who called attention to this phase of the problem, found that borax dips were effective in preventing serious losses due to this disease, and Cook (1) suggested that decay in repacked sweetpotatoes could be reduced by recuring them.

This paper presents data obtained in preliminary experiments performed in 1953 and 1954 in which attempts were made to control soft rot by using fungicidal dips and by recuring for various periods.

PROCEDURE

In all experiments Porto Rico sweetpotatoes which had been cured for approximately 6 days at 85°F following harvest and stored for at least 3 months were removed from storage and passed over the grading belt from which the required number of bushels was selected. In order to reduce variations between samples, single roots were distributed successively from each full basket into as many empty ones. After treatments were completed, baskets were replaced immediately in storage and were left undisturbed until soft rot data were taken. Samples were usually of half-bushel or bushel size, and at least four samples were used for each treatment.

EXPERIMENTAL RESULTS

Fungicidal Dips: Results of two dipping experiments indicated that borax solutions at 1% or 2.5% concentrations were equal to or superior to all other dips tested. Although 1% borax used as a 10-minute soak gave better results than instant dips of the same concentration, the differences were not significant. Washing roots in water without a fungicide did not reduce the incidence of soft rot. Results from one of these tests are in Table 1.

Post Storage Curing: Four experiments were performed in which sweetpotatoes were recured for various periods after they had been removed from storage, graded and handled. Two of these are reported on here. When roots were graded and repacked, exposed to a temperature of 85° F and 60 percent relative humidity or above for 24 hours and returned immediately to storage, a significant reduction in soft rot occurred (Table 2). Roots held for 96 hours under the same conditions developed significantly less soft rot than those stored for 24, but differences between such roots stored for 24, 48, and 72 hours were not significant.

Since sweetpotatoes are usually transported by truck or rail car from storage to the consumer, they are further predisposed to invasion by soft rot fungi because of injuries which occur in transit. In order to compare borax dips and post storage curing under conditions which are more likely to occur in practice, treatments were compared on lots of sweetpotatoes which had been hauled by truck for 80 miles. One lot was also treated with borax prior to transit. Control lots were placed in storage as follows: 1) immediately after grading and packing, 2) dipped in borax prior to storage, 3) trucked 80 miles and stored without treatment.

Results of observations made at the end of 12 and 21 days are shown in Table 3.

Data taken at the end of 14 days showed that all treatments except the 24-hour cure significantly reduced soft rot in lots which had been hauled. Recuring appeared to be as effective as the borax treatment. There appeared to be no difference in the borax treatment whether applied before or after transit under the conditions of this experiment. Observations after 21 days showed the same general trend as those made earlier.

DISCUSSION

These preliminary data which are based on 6 experiments performed during 2 seasons indicate that losses in repacked sweetpotatoes can be reduced by recuring or by treatment with borax. When sweetpotatoes are being sold for table stock, recuring would appear to have advantages over treatment with borax.

Responses obtained by recuring would be expected to vary with different lots of sweetpotatoes. The degree of curing after harvest and care during storage would no doubt be important factors affecting soft rot control. The need for further studies combining recuring time with methods of handling are also indicated.

Literature Cited

1. Cook, H. T. 1953. The fungi that cause rot in sweet potatoes. Yearbook of Agriculture. 444-447. U. S. Government Printing Office. Washington, D. C.
2. Daines, R. H. 1942. Soft rot of sweet potatoes and its control. New Jersey Agr. Exp. Sta. Bull. 698.
3. Harter, L. L., J. L. Weimer, and J. I. Lauritzen. 1921. The decay of sweet potatoes (Ipomea batatas) produced by different species of Rhizopus. Phytopath. 11: 279-284.
4. Lauritzen, J. I., and L. L. Harter. 1923. Species of Rhizopus responsible for the decay of sweet potatoes in the storage house and at different temperatures in infection chambers. Jour. Agr. Res. 24: 441-456.
5. Person, L. H., E. O. Olson, and W. J. Martin. 1948. Effectiveness of fungicides in controlling black rot of sweet potatoes. Phytopath. 38: 474-479.
6. Snedecor, G. W. 1946. Statistical methods. The Collegiate Press, Inc. Ames, Iowa.

CLEMSON EDISTO EXPERIMENT STATION, BLACKVILLE, SOUTH CAROLINA

YELLOWS-RESISTANT CABBAGE VARIETIES IN ARIZONA[1]

Robert B. Marlatt[2]

Summary

Cabbage varieties were grown in soil which was heavily infested with the cabbage-yellows fungus, Fusarium oxysporum f. conglutinans, and were compared as to yellows-resistance, yields, earliness, head density, sunburn and frost damage, head size, puffiness, aphid damage, and formation of multiple heads. During the first year of the experiment yellows was severe; during the second year only a trace of the disease developed because of cooler weather.

The Golden Acre variety suffered a maximum loss of 18.1 percent due to the yellows disease whereas the varieties Resistant Golden Acre, Resistant Detroit, Medium Copenhagen, Marion Market, and Red Hollander were comparatively disease-free.

Resistant Golden Acre, Medium Copenhagen, Resistant Detroit, and Golden Acre showed significantly higher total yields than Marion Market, which in turn yielded better than Badger Market. Early yields were highest with Resistant Golden Acre and Medium Copenhagen, next came Golden Acre and Resistant Detroit, followed by Marion Market and Badger Market.

Head density (weight divided by diameter) was greatest in Golden Acre, Resistant Golden Acre, and Resistant Detroit, followed by Medium Copenhagen and, least dense of all, Marion Market and Badger Market.

Marion Market, Badger Market, and Medium Copenhagen were comparatively free of sunburn and frost injury on the tops of the heads. Resistant Golden Acre and Resistant Detroit showed moderate damage and Golden Acre exhibited the greatest injury.

Head diameters of Badger Market were significantly smaller than those of Marion Market and both of these were smaller than the rest of the varieties.

Golden Acre had a greater tendency to form puffy heads than did the other varieties.

No significant varietal differences were found in the amount of aphid damage or in the number of multiple heads.

Cabbage yellows, caused by Fusarium oxysporum f. conglutinans (Wr.) Snyder & Hansen, was severe during the fall of 1952 and 1953 in a few fields in Arizona's Salt River Valley. Losses of as high as 20 percent were found in fields which were planted in August. Fields planted in late September or in October showed only traces of the disease.

During 1953 and 1954 six early yellows-resistant cabbage varieties were planted in heavily infested soil and were compared to the most commonly grown early variety, Golden Acre. Experimental plots were placed in a grower's field and received the standard cultural practices, except for planting and weeding, carried on in Arizona's irrigated areas. Each variety was planted in two rows along a 30-foot portion of a raised, 40-inch bed and each of these six treatments was replicated six times in a Latin square design. Varieties that were planted included Golden Acre, Resistant Golden Acre, Resistant Detroit, Marion Market, Medium Copenhagen, and Red Hollander.

The owner of the field was understandably unwilling to let his entire field remain idle while waiting for the Red Hollander variety to mature in 1953. Therefore, Badger Market, an earlier variety, was substituted for Red Hollander during the 1954 experiment.

Disease Resistance: Disease readings were made by calculating the percentage of plants in each treatment which showed symptoms of the yellows disease. Plots were examined for yellows five times during the season. The highest incidence of diseased Golden Acre plants (18.1 percent) was noted on October 17, 1953 in plots which were planted August 18. The other varieties -- Resistant Golden Acre, Resistant Detroit, Marion Market, Medium Copenhagen, and Red Hollander -- were unaffected by the disease. In 1954, when plots were planted in September and were not exposed to extreme heat, so few plants showed yellows symptoms that no disease readings were made.

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[1] Arizona Agricultural Experiment Station Technical Paper No. 358

[2] Assistant Plant Pathologist, University of Arizona Agricultural Experiment Station, Mesa

Recording the Results: Cabbage was harvested twice at intervals 2 weeks apart at which time records were made of the total number of marketable heads and the average diameter and weight of the heads. The amount of frost or sunburn damage to the tops of the heads was recorded as well as the severity of aphid damage. The recorded differences were compared by use of the analysis of variance for determining statistically significant variations.

Total Yields: Total yields were recorded as the total number of marketable heads that were cut during the two harvest operations. These yields were used only for purposes of comparison and were not expressed on a per-acre basis because the plots were hand planted and weeded and would therefore vary somewhat from plantings made on a commercial scale. Resistant Golden Acre, Medium Copenhagen, Resistant Detroit, and Golden Acre all showed significantly higher yields than Marion Market, which in turn proved better than Badger Market. It should be kept in mind that the yield of Golden Acre was higher than it would have been had the 1954 planting been made earlier with a resulting higher incidence of yellows.

Early Yields: Early yields were determined by a comparison of the total heads cut during the first harvesting date. Resistant Golden Acre and Medium Copenhagen ranked highest; Golden Acre and Resistant Detroit ranked significantly lower; and Marion Market and Badger Market yielded the least.

Head Density: The head density of each variety was rated by dividing the average head weight by the average diameter. An analysis of the resulting figures showed that Golden Acre, Resistant Golden Acre, and Resistant Detroit were the most dense. Medium Copenhagen was less solid and Marion Market and Badger Market ranked last.

Sunburn and Frost Damage: The number of plants which suffered sufficient damage to the tops of the heads to make them unmarketable was recorded for each plot and the results were analysed. It was found that Marion Market, Badger Market, and Medium Copenhagen were comparatively free of injury; Resistant Golden Acre and Resistant Detroit showed moderate damage and Golden Acre was especially susceptible to this sort of injury.

Head Size: By analysing average head diameters it was found that Badger Market was significantly smaller than Marion Market and both of these were considerably smaller than the remainder of the varieties.

Abnormal Heads: In 1953 cabbage in the Salt River Valley displayed a tendency to form uneven, soft heads. The abnormality appeared to be due to a folding and curling of the margins of the leaves so that they could not overlap tightly. The number of heads which displayed this condition were recorded and an analysis of the results showed that a significantly greater number of the puffy heads were found in the Golden Acre variety than in the others.

No significant varietal differences were found in the amounts of aphid damage or in the number of multiple heads.

Discussion

Results of the two-year variety trials indicate that the cabbage varieties Resistant Golden Acre and Resistant Detroit can be successfully grown on yellows-infested land in the irrigated desert areas of Arizona. The variety which is most commonly planted in Arizona for an early fall crop, Golden Acre, was not only very susceptible to yellows, but also was inferior to Resistant Golden Acre and Resistant Detroit in regard to earliness, weather damage, and puffy head formation.

The Badger Market variety apparently is not adapted to Arizona's desert regions, as evidenced by its poor yield, extremely light-weight heads, small size, and failure of the head leaves to reach a sufficient size for overlapping at the top of the head.

UNIVERSITY OF ARIZONA AGRICULTURAL EXPERIMENT STATION, MESA

THE OCCURRENCE OF TWO TYPES OF HYPOCOTYL DISCOLORATION OF HARVESTED RADISHES

B. D. Thompson and Phares Decker[1]

During the 1953-54 season, there were many reports to the effect that prepackaged radishes were severely discoloring during the marketing process.

Investigations in May of 1954 showed that one type of discoloration was largely present at the time of harvest. This type is shown in Figure 1, and was identical with the type which, according to Ramsey et al. (1), can be caused by downy mildew (Peronospora parasitica). In later tests, the fungus grew and fruited quite readily when affected radishes were stored at 60°F. Downy mildew was also observed growing profusely on the hypocotyl and foliage of radishes in the field during cool, moist periods. On the red globe-type of radishes a purplish to greyish-black, blotchy discoloration was caused by this organism. The discoloration was generally noted on the upper half of the radish. The surface of the affected radishes were sometimes rough and cracked. The internal tissue was greyish-brown to black streaked and firm.

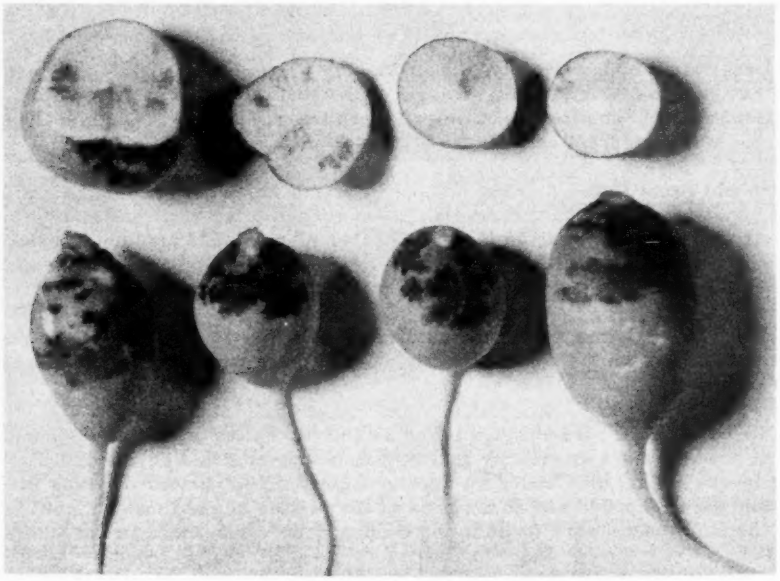

FIGURE 1. Radish discoloration caused by Peronospora parasitica.

Ramsey et al. (1) showed that spores on the surface of healthy radishes could cause infection and discoloration. In our tests to date there have been few indications that transmission of the organism to healthy radishes in a package was a serious problem. The discolored areas present at the time of packaging continued to enlarge slightly and intensify in color at 40°, 50°, or 70°F storage, but non-infected radishes remained free of discoloration. Therefore, field control of the disease and careful grading could largely eliminate this type of radish discoloration in the market.

A second type of hypocotyl discoloration is shown in Figure 2. This type was characterized by small, sunken spots with well defined margins. These spots frequently coalesced and were greyish-brown to black in color with the centers usually of a lighter shade. They may occur any

[1] Respectively, Assistant Horticulturist and Plant Pathologist, Florida Agricultural Experiment Station, Gainesville, Florida.

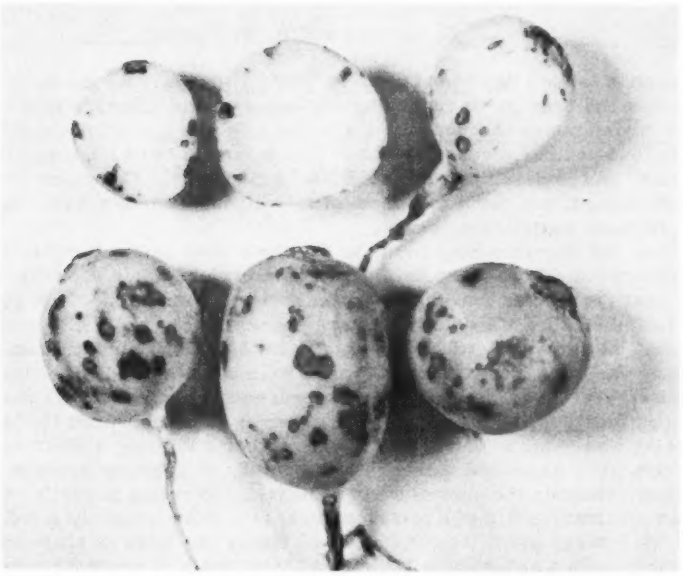

FIGURE 2. Radish discoloration due to unknown causes.

place on the radish. The affected internal tissue was generally black and in various stages of disintegration. The pattern often followed the vascular system, particularly the phloem. Repeated examinations failed to reveal any micro-organisms until the spots reached an advanced stage. At this time many bacteria that are believed to be secondary organisms appeared. As yet there are few indications as to the cause of this discoloration.

This type of radish discoloration was quite sensitive to temperature (2, 3), being completely inhibited at temperatures below 50°F, and retarded by precooling and effective cold storage treatments. These spots did appear on susceptible radishes held at 70°. Radishes produced in Florida in December, 1954 did not develop these spots when held at 70° for 2 weeks. Those grown in late February, 1955 developed discoloration in 4 days at 70° and those harvested in May, 1954 were severely discolored within 2 days at 70°. Effective precooling and maintenance of temperatures near 40°F are suggested for the control of this type of radish discoloration.

Literature Cited

1. Ramsey, G. B., M. A. Smith, and W. R. Wright. 1954. Peronospora in radish roots. Phytopath. 44: 384-385.
2. Thompson, B. D. and L. H. Halsey. 1954. Black-spotting of harvested radishes. Pre-Pack-Age. 8: No. 2, 21, 30; No. 3. 28-30.
3. _____. 1955. Conditions associated with black-spotting of harvested radishes. Florida Agr. Exp. Sta. Horticulture Mimeo. 55-1.

FLORIDA AGRICULTURAL EXPERIMENT STATION, GAINESVILLE, FLORIDA

OBSERVATIONS ON RIB DISCOLORATION AND TIP BURN OF LETTUCE[1]

J. K. Stewart and R. E. Foster

Tip burn of head lettuce has been known for over 30 years. As yet no completely satisfactory explanation has been given regarding the cause of this disease, although it is generally agreed by most investigators that the disease is due to some physiological disorder in the plant.

Since about 1945 another disease has been recognized in head lettuce. This has been termed "rib discoloration" and is described by Dr. B. A. Friedman[2]. The cause of rib discoloration has not been determined, but certain aspects of this disease would suggest that a physiological unbalance is a primary contributing cause.

Because these two diseases may occur at the same time and under identical conditions of culture and environment, there prevails among commercial lettuce growers and certain lettuce research personnel the opinion that the two diseases may be related. It is generally thought that the Great Lakes strains of lettuce are more susceptible to rib discoloration than the Imperial types and that the Imperial strains are more susceptible to tip burn than Great Lakes.

A great many varieties and strains of lettuce have been tested by the University of Arizona. Whenever rib discoloration or tip burn or both occurred in the test plots, the strains were evaluated as to susceptibility to the diseases. The severity of the diseases as they occurred in each of the strains was rated in one of two ways. Either a definite number of heads, usually ten, of each strain were examined thoroughly and rated, or a larger number of heads (30) were examined and those showing the diseases were counted. In rating severity of disease on individual heads, an arbitrary scale of 0 (disease-free) to 5 (very severely diseased) was used. The average of the ratings given the ten individual heads was used as an index of the susceptibility of the variety. Data are given in Table 1 on three trials in which both tip burn and rib discoloration appeared. In the first two tests, severity of the two diseases was judged by use of the arbitrary rating scale. In the third experiment, incidence of the two diseases was determined by counting the number of affected heads out of a 30-head sample.

Three important observations might be made regarding these data. First, it is quite apparent that there is considerable variation between varieties and strains in regard to susceptibility to either of the two conditions. This leads to the assumption that through selection or breeding, less susceptible strains might be developed. Second, the commonly accepted generalization that the Imperial types of lettuce are more susceptible to tip burn while the Great Lakes types show more rib discoloration is not necessarily true. The data show that, under the conditions of the tests, Imperial 615 developed less tip burn than certain Great Lakes strains and also showed a more severe form of rib discoloration than certain of the Great Lakes types. Third, correlation coefficients calculated for each of the three tests clearly indicate that there is neither a significant relationship between severity of tip burn and severity of rib discoloration, nor a correlation between occurrences of these two diseases.

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[1] Arizona Agricultural Experiment Station Technical Paper No. 359.

[2] Friedman, B. A. 1954. Brown spot complex of head lettuce on eastern markets. Plant Dis. Reptr. 38: 847-851.

Table 1. Varietal reaction in lettuce to tip burn and rib discoloration in three different experiments.

VARIETY Source	Stock	Mesa, 1951		Higley, 1952		Mesa, 1953	
		T.B.[a]	R.D.[b]	T.B.	R.D.	T.B.H.[c]	R.D.H.[d]
GREAT LAKES							
Ferry Morse	32370	1.2	1.1				
	8954	2.4	3.0				
	32844					22	10
	366 A			0.2	0.0	19	4
	366 G			0.4	0.2		
	366 H	1.9	2.2	1.2	0.4	17	4
	366 I	2.5	2.2				
	246			0.2	0.0		
	T8954			1.1	0.3		
	9144			1.2	0.5		
	1170			1.6	1.0		
	1179			0.5	0.8		
	1180			1.2	1.0		
	1181			0.4	0.5		
	1204			0.6	0.6		
Associated	97139	2.1	0.9				
	47075	1.8	3.5				
	27118					20	17
Pieters Wheeler	2440	2.2	1.1				
Desert	407	1.5	1.5				
	659	1.7	1.0				
GREAT LAKES 54							
Ferry Morse	13315					23	6
GREAT LAKES 59							
Associated	47083	2.0	1.2			16	14
	67095			0.9	0.0		
PREMIER							
Rohnert	2894	2.5	1.7				
Ferry Morse	24438	2.4	1.6				
PREMIER							
Ferry Morse	32869	1.6	0.9				
	0207			0.9	0.4		
	32998					22	6
Pieters Wheeler	--	1.9	1.2				
Associated	47081			0.6	0.4		
GREAT LAKES 428							
Desert	428	2.6	2.1				
Loomis	1-505			0.8	0.0		
PROGRESS							
Germain	2477	2.1	0.2				
Associated	27152	1.4	0.5				
PENNLAKE							
Ferry Morse	24318	3.6	1.2				
Pieters Wheeler	--	4.2	0.7				

Table 1. (Continued).

VARIETY Source	Stock	Mesa, 1951 T.B.[a]	Mesa, 1951 R.D.[b]	Higley, 1952 T.B.	Higley, 1952 R.D.	Mesa, 1953 T.B.H.[c]	Mesa, 1953 R.D.H.[d]
LAKE SUPERIOR							
Woodruff	--	2.5	1.2				
A-36							
Woodruff	1-32A	1.7	1.4	0.1	0.1		
	316					23	12
K- 1							
Ferry Morse	34362			0.7	0.8		
	1072			0.8	0.0		
IMPERIAL 615							
Ferry Morse	383			1.0	0.0		
	104 K	1.6	2.3				
	32969	2.3	2.5				
	385			1.4	0.0		
	11382					23	6
Univ. Ariz.	51-615F			1.4	0.0		
Associated	27563			1.2	0.0		
SPECIAL							
Univ. Ariz.	71501	2.5	1.3				
T. W. Whitaker	19624M	2.3	0.5				
	20965			1.0	1.0		
	19551			1.2	0.0		
	45634M					25	3
	46162M					28	4
	22199M					21	2
R. C. Thompson	3867	1.3	0.5	0.0	0.0	11	11
	3053	2.6	0.0				
	3186	1.6	0.6	0.8	0.1	26	1
	3188			0.8	0.0	24	13
	4164			0.8	0.0	19	4
	3977					23	2
M. T. Lewis	90	2.0	1.8				
	117	0.5	1.8				
Correlation coefficent (calc)		+0.0093		+0.170		-0.274	
Required for significance (5%)		0.361		0.374		0.482	

[a] Tip burn (ratings).

[b] Rib discoloration (ratings).

[c] Number of tip burn heads in a 30 head sample.

[d] Number of rib discolored heads in a 30 head sample.

ARIZONA AGRICULTURAL EXPERIMENT STATION

A PRELIMINARY REPORT ON DISEASES OF LETTUCE IN THE EVERGLADES AND THEIR CONTROL

R. S. Cox

Abstract

Three diseases, downy mildew (Bremia lactucae), bacterial soft rot (Erwinia sp(p.)), and rib breakdown, seriously jeopardize the lettuce industry in the Everglades of Florida.

Experimental work showed that zineb adequately controlled downy mildew, and streptomycin applied as a dip or painted on the butts of the heads showed real promise in control of the soft rots. Neither the cause nor control of rib breakdown is known, but its similarity to brown blight is noted.

Three diseases have placed the lettuce industry in the Everglades of Florida in serious jeopardy. These are (I) downy mildew, (II) bacterial soft rot, and (III) breakdown of the midrib and other leaf tissues. The combined action of these three diseases results in greatly reduced yields. Frequently, entire fields are abandoned. Also, they affect quality as reflected in reduced size and in poor storage qualities. Progress has been made during the current season in control of two of these diseases.

Downy Mildew

Downy mildew (Bremia lactucae Regel) is the primary and frequently sole disease during the winter months up through February. If cool wet weather persists, as happened in the spring of 1954, the disease may remain a serious problem into March and April.

Fields are sometimes abandoned because of the severity of downy mildew, but reduction in head size is its chief adverse effect. The importance of this is readily seen by the fact that number 5's (five dozen heads/crate), if they sell at all, will only bring about one-half as much as number 4's or 3's. Obviously the smaller the head the fewer the crates per acre will be realized.

In a replicated experiment involving six fungicides, zineb was significantly better than any other material (approximately 60 percent increase over the check). Captan (39 percent increase) and ferbam (34 percent increase) were second best and significantly better than the check. Tribasic copper sulfate and chloranil gave appreciable disease control, but the beneficial effects were completely nullified by phytotoxicity. PCNB caused severe injury and effected no disease control at all.

Bacterial Soft Rot

Bacterial soft rot (Erwinia sp(p.)) becomes manifest following a period of warm weather. Two distinct phases of the disease are common; namely, "slime head" and "butt rot" or "jelly butt" (Figures 1 and 2). Both occur in serious proportions in the field and in transit. A grower may be plagued with either or both of the diseases. This possibly is due to different species of the soft rot bacteria being involved; however, differences in cultural and packing practices are believed to play an important role.

Smith[1] showed that streptomycin sulfate (1000 ppm) was highly effective against bacterial soft rot of packaged spinach. Work was undertaken to determine the effectiveness of streptomycin as a post-harvest treatment against soft rot of lettuce. The commercial product, Agrimycin-100, containing streptomycin sulfate and Terramycin in a 10-1 ratio and manufactured by Charles Pfizer Company, was used in all tests. Also a streptomycin nitrate formulation, Phytomycin, manufactured by Mathieson Chemical Corporation, as well as another streptomycin sulfate formulation by Merck and Company, Inc. were used in limited tests. All three products performed equally.

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[1]Smith, Wilson L. Jr. 1955. Streptomycin sulfate for the reduction of bacterial soft rot of packaged spinach. Phytopath. 45:88-90.

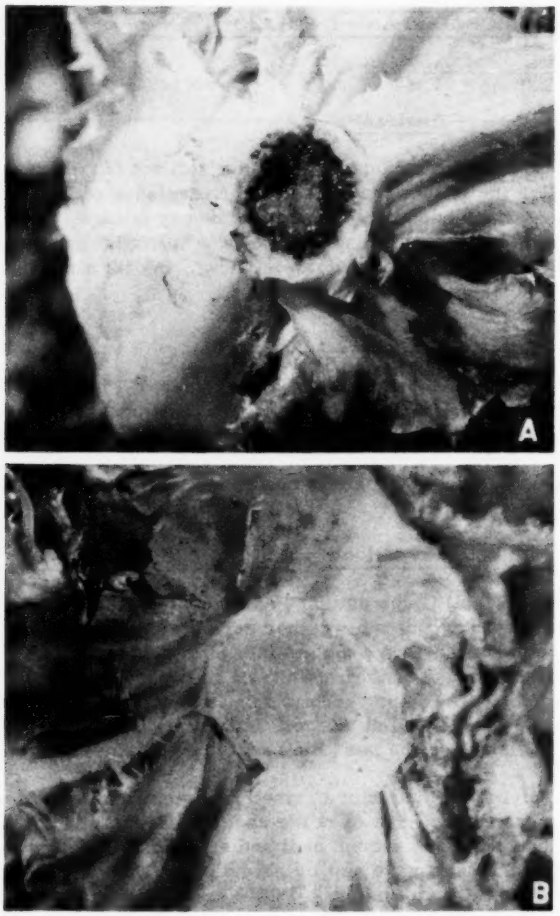

FIGURE 1. Jelly butt symptoms developed on lettuce in storage:
A. Diseased.
B. Healthy.
Photographs by Henry L. Spelman, III.

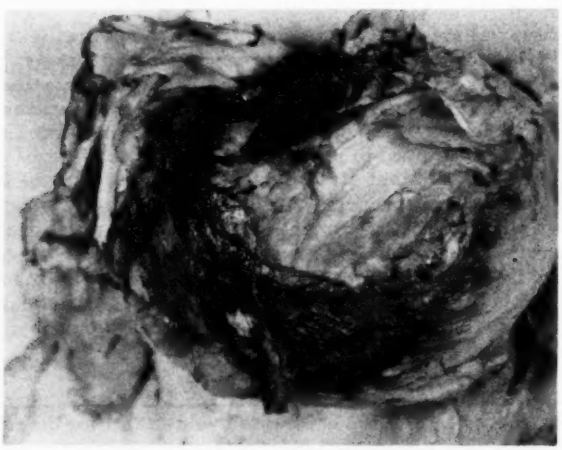

FIGURE 2. Slime head symptoms developed on lettuce in storage. Photograph by Henry L. Spelman, III.

In the experimental procedure the heads were dipped momentarily in the desired solution, crated and then placed underneath a tarpaulin in an area exposed to direct sunlight where they were kept for a minimum of 48 hours. Maximum temperature observed under the tarpaulin was 85°F. No artificial inoculations were used.

All concentrations, 50 ppm up to 1000 ppm, were highly and equally effective against both slime head and jelly butt. Infections ranged up to 60 percent in the untreated and from 2 to 9 percent in the treated.

In one test involving a field where jelly butt was the primary disease, butts were painted with a 250 ppm solution of streptomycin as the lettuce was packed in the field. Infection was reduced from 62 percent in the untreated to approximately 4 percent in the treated.

Lettuce of one grower was affected primarily with slime head. A test was set up where the heads were dipped momentarily in concentrations of 10, 25 and 50 ppm streptomycin. After 2 days, 85 percent of the untreated heads had become slimy, whereas percentage infection ranged from 6 to 12 percent in the treated. The 10 ppm concentration was almost as effective as 50 ppm.

Rib Breakdown

Rib breakdown became prevalent in the spring of 1955 after hot weather set in. Brown streaks appeared along the rib and veins of the leaf, later followed by soft rot. The cause of this disease is unknown. Isolations so far have been negative. In many respects it is not unlike the brown blight described by Jagger[2] in 1940. It progresses during transit and greatly impairs the lettuce display in the retail market. No attempt at control has been made.

Discussion

Except for the diseases mentioned, the Everglades area is ideally situated for the production of high quality lettuce. Thus, control of these diseases should provide a real impetus to the industry. A satisfactory solution to the downy mildew problem appears to be in sight.

It would also appear that the bacterial soft rots could be adequately controlled in transit with formulations of streptomycin. As pointed out by Smith[1], however, antibiotics should not be used on leafy vegetables in particular until approval is granted by the Food and Drug Administration. Painting of the butts, where feasible, of such vegetables as herein reported could provide one solution to the problem. Another could be through the use of the material as a dip at very low (10 ppm) concentrations.

EVERGLADES EXPERIMENT STATION, UNIVERSITY OF FLORIDA, BELLE GLADE, FLORIDA

[2] Jagger, Ivan C. 1940. Brown blight of lettuce. Phytopath. 30:53-64.

NEW HOSTS ARTIFICIALLY INOCULATED WITH SCLEROSPORA SP., AGENT OF A NEW SUGAR CANE DISEASE IN PERU[1]

Victor A. Revilla M.[2]

Investigations started at the beginning of 1952 by the Department of Plant Pathology of the Agricultural Experiment Station La Molina, on the new disease of sugar cane that appeared in Peru, caused by a species, possibly a new species, of Sclerospora, were successful in obtaining artificial infection of the wild and cultivated grasses listed in Table 1. Negative results were obtained from inoculation of some other grasses, including corn, wheat, rye, rice, Kikuyo grass, and others.

Table 1. Grasses artificially infected by Sclerospora sp. in Peru.

Common name	Species	Tribe
Para Grass	Panicum barbinodes Trin.	Paniceae
Cresta de Gallo	Echinocloa colonum L.	Paniceae
Pega Pega	Setaria verticillata L. (Bv)	Paniceae
Johnson Grass	Sorghum halepensis L. Pers.	Andropogoneae
Sorghum	Sorghum vulgare var. sudanensis Piper.	Andropogoneae
Job's tears	Coix lacryma-jobi L.	Maydeae
Pata de Gallina	Eleusine indica L. Gaertn	Chlorideae
Grama Dulce	Polypogon interruptus H.B.K.	Agrostideae

Symptoms: In general, the grasses listed in Table 1 showed stunting or dwarfing, very marked chlorotic streaks on the leaf blades, and distortion of spikes and panicles.

In the majority of these new hosts of this Sclerospora sp., the conidial stage of the fungus was observed more abundantly and conspicuously than in sugar cane. The great abundance of conidial formation on these plants leads us to consider them as highly infective hosts, playing thus a very important role in the perpetuation and dissemination of the disease to sugar cane plants.

ESTACION EXPERIMENTAL AGRICOLA DE LA MOLINA, PERU

[1]Published in "Azucar", Vol. III, No. 8, March 1954. Lima, Peru.

[2]Head of Plant Pathology Department, Experimental Station La Molina, Lima, Peru

THREE DISEASES OF LIPPIA CANESCENS NEW TO ARIZONA[1]

Alice M. Boyle

Summary

Three diseases of Lippia canescens are described. The first establishes a new host for the crown gall bacterium, Agrobacterium tumefaciens, and the second is the first report of black mildew, Meliola sp., on this host in Arizona. The third, southern blight caused by Sclerotium rolfsii (Pellicularia rolfsii) has not been noted before in Arizona.

Lippia canescens H. B. K., a creeping, spreading member of the Verbenaceae, is used widely as a ground cover in Southern California and Arizona. Except for its susceptibility to root-knot nematode infection (Meloidogyne sp.), this plant has, in Arizona, been disease-free and therefore quite satisfactory for use as a lawn plant in certain situations. However, during 1953 and 1954, three diseases of Lippia have come to our attention which, if allowed to become widespread, may make the use of this plant undesirable.

Crown Gall

In June, 1953, Lippia plants with root and crown galls of various sizes up to 4 inches in diameter were sent from Phoenix to the University of Arizona Department of Plant Pathology (Fig. 1). Cultures of the gall tissues yielded, often in pure culture, a bacterium. When Kalanchoë daigremontiana plants were inoculated with the bacterium, typical crown gall symptoms developed (Fig. 2).

Laboratory tests showed the Lippia isolate to have the following physiological and morphological characteristics: 0.5-0.7 x 1.0-2.5 microns, motile by polar flagella, and gram negative. Colonies on potato dextrose agar: gray-white, circular, entire, glistening, translucent. Slight acid but no gas from glucose, fructose, arabinose, galactose, and mannitol. Milk coagulated but not peptonized; litmus milk reduced. Nitrates slightly reduced. Hydrogen sulfide, indol and ammonia produced. It will be noticed that, except for slight difference in size, the Lippia bacterium is identical with Agrobacterium tumefaciens (E. F. Sm. & C. O. Townsend) Conn (1, 2).

Since the first specimens of Lippia showing galls were obtained in June, 1953, the disease has been found in three plantings in the Phoenix area and in one near Tucson. Since spread to susceptible trees and shrubs would be facilitated by the presence of crown gall infected Lippia plants in a garden, the discovery of this new host of the crown gall bacterium gives us considerable concern.

Black Mildew

In the summer of 1953 a large Lippia planting near Phoenix was practically killed by a fungus which invaded the stems and leaves of the plants, causing conspicuous black blotches (Fig. 3). When some of the diseased plants were examined after being kept for a week in a moist chamber, black to dark-brown perithecia had developed. A study of these together with certain other characteristics of the fungus made possible its identification as a species of the genus Meliola. Although the members of this genus are reported to be usually entirely superficial and seldom causing discernible pathological effects (5), in this instance the fungus often invaded the growing point of the host plant, causing complete blackening of tissues and finally death.

Black mildew caused by Meliola lippiae Maubl. has been reported from Florida (3) but has been hitherto unreported in Arizona.

The description of the Arizona fungus follows:

Mycelio hyalino in iuventa, brunneo in senectute et constricto ad septa, 5-9 u d. Hyphopodiis alternantibus, bicellatis, capitatis. Setis in mycelio numerosis, simplicibus, acutis. Peritheciorum setis absentibus. Peritheciis aggregatis, globosis, brunneis vel nigris,

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[1]Arizona Agricultural Experiment Station Technical Paper No. 360

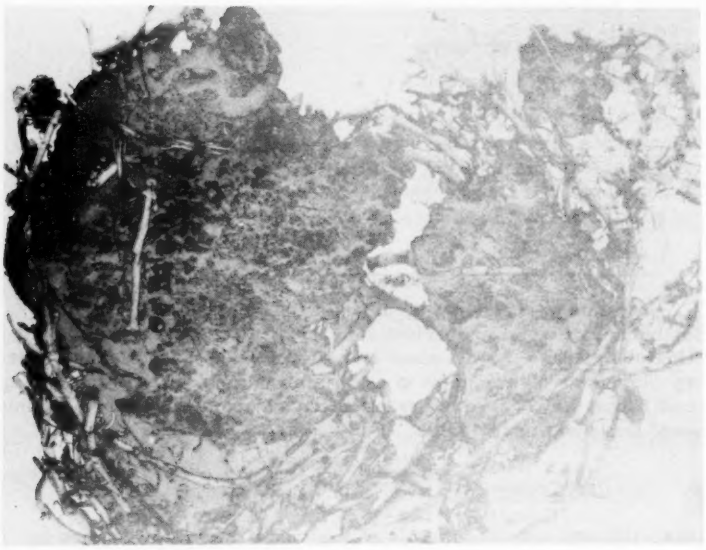

FIGURE 1.
Galls on roots and lower stems of Lippia plants.

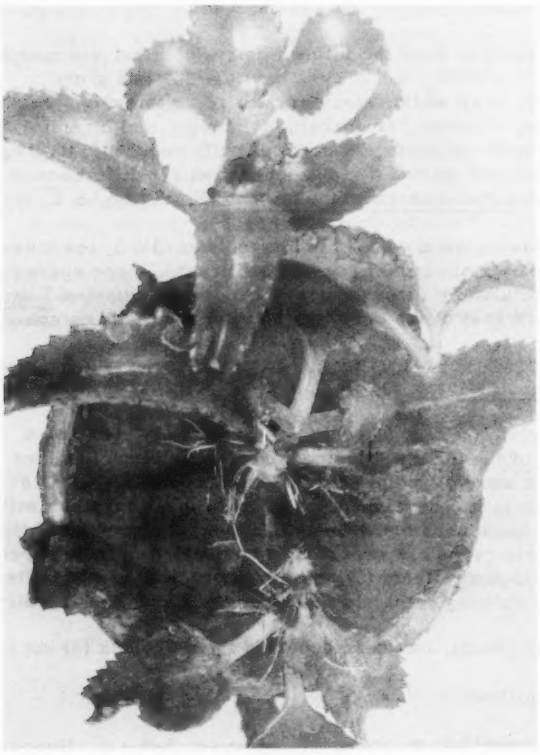

FIGURE 2. Kalanchoë daigremontiana showing galls produced by inoculation with bacterium isolated from Lippia galls.

FIGURE 3.
Black mildew on Lippia canescens.

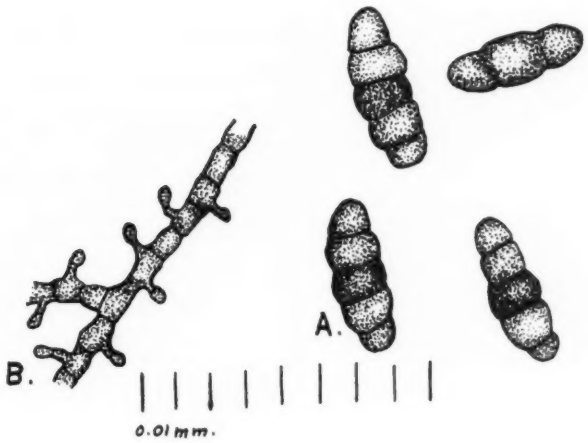

FIGURE 4. Meliola lippiae: A. Ascospores; B. Hypha showing characteristic hyphopodia.

220-285 µ. Ascis clavatis, 2-4 sporis. Ascosporis fuscis, 4-septatis, media cellula fusciore quam reliquis, ad septa constrictis, 30-35 x 14-16 µ.

Mycelium hyaline when young, becoming dark brown with age and constricted at the septa, 5-9 µ diameter. Hyphopodia alternate, 2-celled, capitate. Setae in mycelium, many, simple, acute. No perithecial setae. Perithecia gregarious, globoid, dark-brown to black, 220-285 u. Asci clavate, 2-4 spored. Ascospores dark, 4-septate, center cell darker than others, constricted at septa, 30-35 x 14-16 µ.

Following is the description of Meliola lippiae Maubl. (4):

"Mycelio maculas orbiculores, nigras, tomentosas efficiente, ex hyphis atrofuscis, 8-9 µ crassis composito. Hyphopodiis capitatis alternantibus, 26-30 x 10-12 µ, cellula superiore ovoidea. Setis in mycelio numerosis, nigris, opacis, uncinatis, obtusis, 10 µ crassis. Peritheciis aggregatis, globosis, nigris, verruculasis, 125-220 µ d. Ascis obovatis, 2-sporis. Sporis ellipticis, 4-septates, ad septa constrictis, obtusis, atrofuligineis, 26-30 x 12-14 µ."

It is evident after a comparison of the two descriptions that there are dissimilarities, size of perithecia and ascospores being the most conspicuous difference. The position and characteristics of hyphopodia, septation of ascospores, and the presence of numerous setae on the mycelium and their absence on perithecia are in agreement. The Meliola sp. here described would fall into Section E of Stevens (5), the members of which are characterized by having 4-septate ascospores, simple mycelial setae and no perithecial setae or other appendages. Because environment may often influence spore size, it seems desirable, rather than designate the Meliola on Lippia as a new species, to retain it in the established species, Meliola lippiae Maubl.

Southern Blight

Southern blight, caused by Sclerotium rolfsii Sacc. (Pellicularia rolfsii (Curzi) West) has been reported from California on Lippia canescens (3). Until the summer of 1954, the disease had not been observed in Arizona. At that time a large planting of Lippia located near Phoenix was found to be badly infected with the southern blight fungus. Little remained of the lawn and the nearly bare ground was covered with the mustard seed-like sclerotia of Sclerotium rolfsii.

Literature Cited

1. Bergey's Manual of Determinative Bacteriology, 1948. 6th ed. The Williams and Wilkins Co. Baltimore, Md.
2. Elliot, Charlotte. 1951. Manual of Bacterial Plant Pathogens. 2nd ed. Chronica Botanica Co. Waltham, Mass.
3. Index of Plant Diseases in the United States. 1953. U. S. Dept. Agr. Beltsville, Md.
4. Maublanc, A. 1903. Sur quelques especes nouvelles de champignons inferieurs. Bul. Soc. Myc. de France 19: 291.
5. Stevens, F. L. 1916. The genus Meliola in Porto Rico. Illinois Biol. Mon. 2: 1-86.

DEPARTMENT OF PLANT PATHOLOGY, UNIVERSITY OF ARIZONA, TUCSON, ARIZONA

LONGEVITY OF ENDOCONIDIOPHORA FAGACEARUM IN LUMBER

Oren W. Spilker[1] and H. C. Young[2]

Abstract

The longevity of Endoconidiophora fagacearum in lumber retaining bark was affected by temperature and moisture content. This fungus was short-lived (3<5 weeks) in lumber blocks subjected to temperatures of 25° and 27.5° C. When the lumber was stored at lower temperatures, longevity increased. At 5° C the fungus was still viable after 12 weeks in the blocks that ranged in moisture content from 19.3 to 86.5 percent. The apparent influence of moisture content on the longevity was such that as the moisture content decreased longevity also decreased.

The suspected danger in spreading the oak wilt fungus (Endoconidiophora fagacearum Bretz) by shipping lumber into disease free areas has resulted in threats of foreign embargoes and interruptions in the normal distribution of oak lumber in the United States. To help prevent these restrictions, which would hinder our lumber industry if imposed, additional information on the longevity of the oak wilt fungus in lumber seemed necessary.

In a previous investigation (5) on the longevity of the oak wilt fungus, it was reported that the fungus was short-lived (<3 weeks) in wood after the moisture content (oven dry weight) had dropped below 60 percent. This investigation was limited to material cut and stored in the field during the extremely hot summer months. Other reports have indicated that temperature and moisture are two of the factors that may have an effect on the longevity of this fungus in wood. Jones and Bretz (2) isolated the oak wilt fungus from lumber with bark that was cut from diseased trees in February and air-dried for 37 days. The lowest moisture content at which the fungus was isolated was 41.1 percent. Bretz and Morison (1) found that time and temperature were critical factors in the longevity of the fungus in twig samples. Branch samples stored at temperatures between 0°-10° C yielded the fungus up to 27 days and at 20°-25° C the fungus was not recovered after 6 days. At 30° C the fungus was not recovered after the sixth day and at 35° C it was not recovered after the third day. The longevity of E. fagacearum in twigs stored by Merek and Fergus (4) in the forest during the summer months was only 3 weeks and only 11 weeks in twigs subjected to various relative humidities and stored at 24° C.

Materials and Methods

Three 6 foot logs from a diseased 12 inch dbh black oak were cut into boards 1 inch thick and 2 inches wide. These logs, which were obtained 4 weeks after wilt symptoms had developed, were quarter cut to obtain as many boards with bark as possible. Only lumber with bark was used because the fungus is found primarily in the region beneath the bark and has never been isolated from lumber without bark (2, 5). Pieces 8 inches long were cut from the boards and from each board samples were taken for culturing and for moisture determinations. The fungus was recovered in 87.7 percent of the pieces sampled prior to storage. Samples for the moisture determinations were prepared (cut and treated) in the manner prescribed by the Forest Products Laboratory (3) for the oven dry weight method. Previous to storage the outer bark on all of the blocks was removed, and the entire block swabbed with alcohol and flamed. Insect riddled or rotted pieces were discarded and not used in this experiment. Four randomly selected blocks were then transferred with sterile tongs to each 2 1/2 gallon wide-mouth pickle jar desiccator (Fig. 1) containing various amounts of calcium oxide. Calcium oxide, used as a desiccant in food packaging (6) was found to be a suitable desiccant for this experiment. The vapor capacity of the calcium oxide used was approximately 38 percent. The quantities of desiccant used to reduce the moisture content of the blocks to certain levels were 1/2, 1 1/2, and 2 1/2 pounds. Eight inch squares of 1/4 inch mesh hardware cloth with the corners bent down for legs were used to support the blocks over the desiccant. A fourth desiccator containing 750 ml of water and used as a check, was added to each set. Lids of the desiccators, containing waxed liners, were sealed with Scotch electrical tape. Four sets of desiccators were stored at temperatures of 5°, 20°, 25° and 27.5° C.

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[1] Division of Plant Industry, Ohio Department of Agriculture.

[2] Department of Botany and Plant Pathology, Ohio Agricultural Experiment Station.

FIGURE 1. A pickle jar desiccator used for storing lumber blocks.

One set was removed from each temperature at intervals of 3, 5, 8, and 12 weeks for culturing and moisture determinations. One block was used to determine the moisture content at the time of removal from the desiccator. The other three blocks were cultured by cutting chips with a sterile chisel and placing 12 chips to each of three or four plates containing acidified potato dextrose agar. The plates were then incubated at 25° C.

A preliminary test was made to determine the best method of isolation. Greater recovery of the fungus and a more rapid growth was obtained when a piece including both bark and wood was cultured. When either wood or bark alone was used, poor growth and less recovery of the fungus was obtained, bark yielding the least.

The method and materials used in obtaining ranges of moisture contents in wood blocks for these longevity studies proved to be very satisfactory. The pickle jars were large enough to hold the blocks and the desiccant without being too heavy or awkward to handle. The handle on the jars facilitated moving them to and from storage. By using certain quantities of calcium oxide, the desired range of moisture content was obtained. Due to the expansion of the calcium oxide, 2 1/2 pounds was the maximum amount that could be used without the blocks becoming wedged in the jars. This inexpensive type of desiccator, and the simplicity of the method used in obtaining ranges of moisture contents may be found useful in other research problems.

Results

The moisture content of the blocks and the recovery of Endoconidiophora fagacearum from them are listed in Table 1. The fungus was isolated from the blocks stored for 3 weeks at 20° and 5° C, but it was only isolated in one instance at each of the higher temperatures. The lowest moisture content at which the fungus was isolated from the blocks at the two higher temperatures was 75.7 percent. After 5 weeks of storage at the two higher temperatures, the fungus was not isolated from the blocks, not even from those with a moisture content above 75.7 percent. The lowest moisture content at which the fungus was isolated from the blocks was 14.5 percent; this was determined after the blocks were stored for 5 weeks at 20° C and then 3 weeks at 11° C. At 5° C the moisture content of the blocks was reduced much more slowly and after 12 weeks of storage the fungus was still viable in the blocks with ranges of moisture contents from 19.3 to 86.5 percent.

Fungus growth developed on a number of blocks in storage. After transfers were made of the fungi present, the blocks were again lightly swabbed with alcohol and flamed. If the fungus growth was heavy on the blocks, more of the bark was removed before being cultured. The fungi isolated from the exterior of the blocks in storage included species of the genera Penicil-

Table 1. The moisture content and presence of E. fagacearum in lumber blocks incubated for 3, 5, 8, and 12 weeks at various temperatures.

Temperature (° C)	Amount of desiccant (pounds)	Periods of storage: 3 weeks Moisture content %	3 weeks Fungus isolation	5 weeks Moisture content %	5 weeks Fungus isolation	8 weeks Moisture content %	8 weeks Fungus isolation	12 weeks Moisture content %	12 weeks Fungus isolation
25	H_2O	89.0	+	88.8	-	86.1	-	84.6	-
	1/2	68.1	-	69.8	-	70.7	-	64.1	-
	1 1/2	39.3	-	41.4	-	44.1	-	43.9	-
	2 1/2	32.4	-	15.1	-	20.0	-	21.9	-
27.5	H_2O	85.5	-	76.0	-	81.0	-	80.0	-
	1/2	75.7	+	66.4	-	68.9	-	60.5	-
	1 1/2	47.6	-	39.0	-	48.3	-	46.1	-
	2 1/2	32.2	-	18.3	-	10.4	-	10.5	-
20	H_2O	85.1	+	86.4	+	85.8	-	86.9	+
	1/2	73.0	+	66.2	+	70.3	-	70.2	+
	1 1/2	48.7	+	46.0	+	39.2	-	33.9	-
	2 1/2	42.9	-	19.6	-	14.5	+	18.6	-
5	H_2O	82.2	-	87.8	+	81.6	+	86.5	+
	1/2	66.7	+	73.8	+	72.8	+	80.4	+
	1 1/2	61.5	+	52.5	+	50.2	+	44.8	+
	2 1/2	57.1	+	46.0	+	39.5	+	19.8	+

*Temperature unavoidably changed to 11° C. after 5 weeks of storage.

lium, Trichoderma, Fusarium, Alternaria, Oospora, and two other unidentified fungi. These and a few other fungi were often isolated when the blocks were cultured. Most of the fungus growth on the blocks occurred on the bark. When the oak wilt fungus was isolated from the blocks, it was obtained whether growth of these other fungi was abundant or slight or whether one or several of the genera were present.

Discussion

From the results obtained, it seems apparent that temperature and moisture content affect the longevity of this fungus. The oak wilt fungus was relatively short-lived in the blocks containing bark when stored at the higher temperatures, and as the temperature decreased the longevity increased. However, as the moisture content decreased the longevity decreased. It is also suggested that the rapidity of drying, due to the effect of temperature, also has an effect on the longevity of this fungus.

Since it appears that high temperatures and low moisture contents are unfavorable for survival of Endoconidiophora fagacearum in lumber, it would appear probable that the lumber salvaged from diseased trees and racked during the summer months would be subjected to high temperatures for sufficient time to render the lumber safe for use without danger of spreading the pathogen into uninfested oak areas. This treatment would be of special importance if care has not been used in removing all bark. Because the fungus in this test survived longer in lumber stored at low temperatures, it is suggested that the fungus may therefore survive longer in lumber salvaged from winter cut diseased trees. Such lumber may, when transported into disease free areas, act as a source of inoculum if it is not treated in some manner. To eliminate this hazard, it may become necessary to enforce the removal of all bark from the lumber, or that lumber be stored for a period of approximately 6 to 9 months, or be kiln dried. With the complete removal of the slab from the logs, the portion that remains then as a source of inoculum is the slab material. Until further information is obtained on the longevity of the fungus in slab piles, it may be necessary to burn all of the slab material removed from diseased trees during the lumbering operation.

It will be noted in the table that certain unexplainable results appear. It is ascertained that with a repetition of this series that these results will level off and more conclusive results will be obtained. The methods designed for this test seem applicable and with repeated tests a great deal more can be learned about the longevity of E. fagacearum in lumber and wood products.

Literature Cited

1. Bretz, T. W., and David W. Morison. 1953. Effect of time and temperature on isolation of the oak wilt fungus from infected twig samples. Plant Dis. Reptr. 37: 162-163.
2. Jones, T. W. 1954. Personal correspondence on work conducted by Dr. Jones and Dr. T. W. Bretz. August 28.
3. McMillen, J. M. 1950. Method of determining the moisture content of wood. Forest Products Laboratory Report No. R1649, 8 pp.
4. Merek, Edward L., and Charles L. Fergus. 1954. Longevity of the oak wilt fungus in diseased trees. Phytopath. 44: 328.
5. Spilker, Oren W. 1953. The longevity of Endoconiophora fagacearum in lumber and other wood products. (Abs.) Phytopath. 43: 485.
6. Talhurt, William F., Carl E. Hendel, and R. R. Legault. 1954. Desiccating in the package. Food Engineering 26: 79-81, 194, 197.

DIVISION OF PLANT INDUSTRY, OHIO DEPARTMENT OF AGRICULTURE, AND DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, OHIO AGRICULTURAL EXPERIMENT STATION.

A SELF-PROPELLED SMALL-PLOT SPRAYER

Andrew J. Culver, Jr.[1]

Summary

Development of a self-propelled, self-powered sprayer for small-plot experimental testing of fungicides and herbicides is described. Design considerations are discussed, and construction outlined and illustrated. Observations relative to the usefulness of the machine under field conditions are made.

Background

Fungicide and herbicide testing at this station[1] is in connection with the enforcement of the Federal Insecticide, Fungicide, and Rodenticide Act. The test samples are not generally large and it is necessary to scale field tests down accordingly. It has been determined that 5 gallons of spray mixture per application will be sufficient for most crops used for testing. This will allow a full field season of spraying at the rates commonly recommended. Accordingly, the spray aliquots have been standardized at 5 gallons.

While many sprayers have been devised for fungicide testing in general, none have been designed for small plots, where many replications and treatments are involved, with a view toward improving the quality and efficiency of routine and experimental spraying. Most methods require more than one man and considerable time. The machine to be described was designed for one man operation for efficient application of spray material, and for ease and speed of application.

Several small power sprayers are available commercially. After using several of these units it is apparent that they serve only as containers in which to mix spray materials with water and as sources of high pressure spray mixture. No means of moving the sprayer to the plant to be sprayed is supplied. This must be done by hand. The tanks are either too large, or too small, and only one tank compartment is furnished. The units are hard to handle on soft ground, and are generally inflexible for many diverse uses.

To overcome the above objections and to solve the sprayer problem at this station, an attempt was made to convert existing equipment to a more usable form in the fall of 1950. A Myers "Silver Prince" wheelbarrow sprayer was changed to a two-wheel trailer and arranged to be towed behind a Gravely tractor. Booms attached to the sprayer, or hand-held guns, were used to apply the spray. This arrangement was used for three seasons. Several objections to this equipment were noted during this period. The units were too long to haul in a pick-up truck without uncoupling. Two engines had to be kept in running order. The pump had too low a capacity, and the tank had only one compartment. Other more important objections were that the unit had a minimum turning radius of 15 feet and was difficult to drive on soft ground.

At the end of the 1953 field season it was decided to construct a sprayer which would eliminate most of these objections. After three years of experience with self-propelled equipment, it was evident that there was a definite place for it in the program here if a satisfactory machine could be built.

Design Considerations

The sprayer is self-propelled and the operator rides. The wheel arrangement is tricyclic, permitting a short turning radius. Wheel tread is 28 inches over-all. Steering requires only one hand. Drive is through the rear wheels and a differential is required. A range of forward speeds and reverse is available. The spray pump has a 3 gallon per minute capacity at 250 pounds per square inch. The tank consists of two 5 gallon compartments with a V-bottom to permit dry pumping. Tank openings are full width with hinged lids, giving access for cleaning and maintenance. Removable inner lids of stainless steel have bronze screens at one end and also serve as splash guards. The agitator is rotary and centered over the vee. The engine is

[1]Plant Pathologist, Fungicide & Herbicide Unit, Pesticide Regulation Section, Plant Pest Control Branch, Agricultural Research Service, U. S. Dept. of Agriculture, Corvallis, Oregon

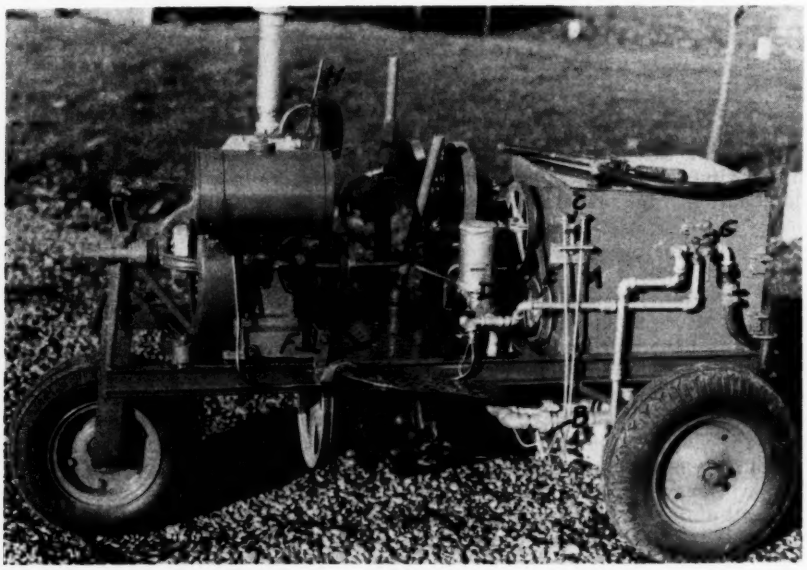

FIGURE 1. Illustrates the push rods (A) which operate the tank valves (B) feeding the pump. Only one push rod can be held down at one time by the swinging latch (C). Other vital parts of the sprayer are the pressure regulator (D), agitator shaft (E), clutch pedal (F), and three-way valve for spray control (G). The throttle is noted at (H).

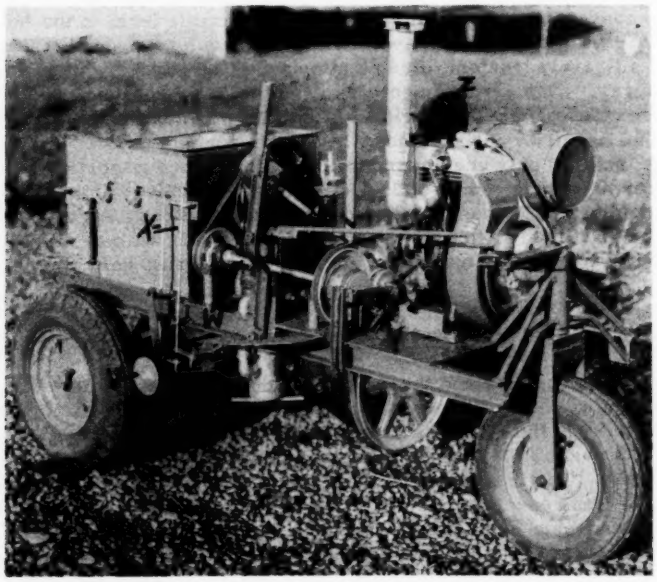

FIGURE 2. Illustrates at (X) the levers operating the tank dump valves, the clutch idler (Y), and pressure gauge (Z), and jackshaft (W) and the speedometer drive wheel (V).

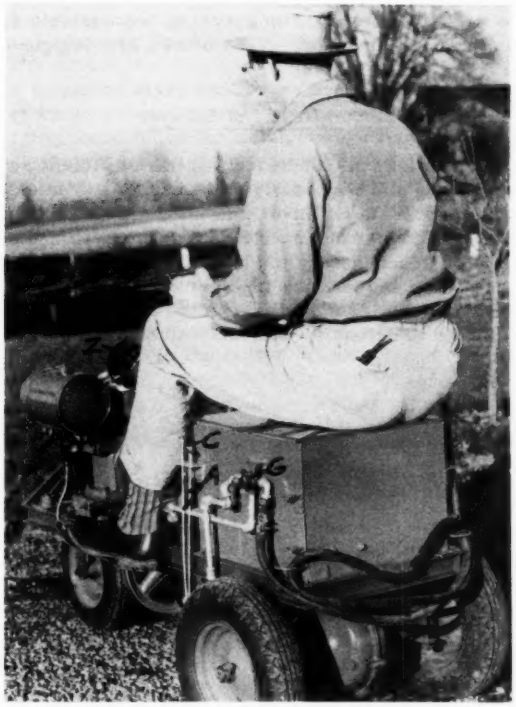

FIGURE 3. Shows the position of the operator and the rear of the machine. To adapt the machine to various types of crop spraying demountable spray booms were devised. A Hardie hand gun is used for tree work. The booms are designed to fold forward and latch in that position for traveling.

of sufficient power to operate the unit at all speeds and pressures desired. All controls are accessible from the operator's seat atop the tank, including tank and dump valves.

The sprayer was constructed during the fall of 1953. The engine is a Briggs and Stratton model "A", rated at 1 h.p. The rear end is a Ford model "T" cut down to 27 inches over-all. The transmission is a Ford model "A". A 12 inch V-belt drive pulley is attached to the front end of the transmission. The frame is a 2-inch mild steel channel, arc welded together, as is most of the sprayer. Space does not permit full construction details but Figures 1 to 3 will illustrate many of them. Certain details should be mentioned. The clutch operates as a simple belt tightener on the belt from the jackshaft to the main drive pulley on the transmission. The jackshaft, running on Fafnir ball-bearing pillow blocks, operates the pump and supplies power to the transmission. It is in turn driven by the engine. The pump is a Hardie model 66, 3 gallons per minute capacity at 250 PSI. The agitator is belt driven from the pump drive shaft. Belt guards for the safety of the operator cover the pump and agitator drive belts when the machine is in operation. These were removed so that the details of construction would show in the photographs. Since exposed moving parts are dangerous to the operator, protection of some sort must be devised.

Figure 1 illustrates the push rods (A) which operate the tank valves (B) feeding the pump. Only one push rod can be held down at one time by the swinging latch (C). Other vital parts of the sprayer are the pressure regulator (D), agitator shaft (E), clutch pedal (F), and three-way valve for spray control (G). The throttle is noted at (H).

Figure 2 illustrates at (X) the levers operating the tank dump valves, the clutch idler (Y), and pressure gauge (Z), and jackshaft (W) and the speedometer drive wheel (V).

Figure 3 shows the position of the operator and the rear of the machine.

To adapt the machine to various types of crop spraying demountable spray booms were devised. A Hardie hand gun is used for tree work. The booms are designed to fold forward and latch in that position for traveling.

Remarks on Utility of Sprayer

The machine has given satisfactory performance. It has sufficient power to climb a 30° grass slope with the operator riding and will easily pull through soft mud. It can turn in a circle with a radius of 5 feet. Depending on throttle setting and gear selection it has a governed speed range from 0 to 6 miles per hour. During the past season, with the proper spray booms or guns, the sprayer was used on peaches, apples, roses, celery, snapdragons, potatoes and alfalfa. With a separate tank, pump and engine, together with a weed spray boom, which hangs on the rear of the sprayer tank as an attachment, herbicide tests were applied. Other useful attachments are being constructed to extend further the value of the machine.

PLANT PEST CONTROL BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE, CORVALLIS, OREGON

TAGGING METHOD FOR RAPID RECOGNITION OF CULTURE TUBES

Harold S. McNabb, Jr. [1]

While conducting a variation study on Fomes annosus (Fr.) Cke., a technical problem arose. In one series of experiments, a large number of culture tubes (as many as 4000) was used. A method of tagging these tubes for quick recognition was needed. Methods in common use, such as coloring the top of cotton plugs, were not feasible in this study because of the large number of different isolates and treatments. The problem was solved by the use of small typewritten tags attached to the cotton plugs with straight pins.

The tags were originally typed in horizontal rows as part of a group on letter-sized paper. Each tag in this study carried the isolate number and the type of treatment. Straight pins were placed through the paper in the middle of this information. After all the pins had been placed in their proper positions, horizontal strips of tags were cut from the sheet of paper. Individual tags were cut from the strips as they were placed in position on the cotton plugs, the pin except for its head being embedded in the cotton (Figure 1).

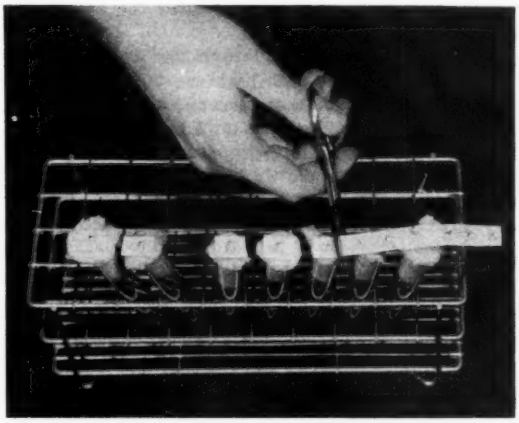

FIGURE 1. Cutting a tag as it is placed in position on a cotton plug.

Two notes of caution should be mentioned concerning the use of this marking method. If tagging is to be done after sterilization, care should be taken to avoid puncturing the bottom of the cotton plug by the tip of the pin. The use of the shortest type of straight pin eliminates this problem in the average sized cotton plug. If this caution is heeded, this tagging method will not introduce any contamination. If the tags are to be autoclaved, stainless steel pins should be used.

Although the tagging method described above required considerable time to assemble, the ease by which the writer could find individual culture tubes from the large number of randomized tubes quickly outweighed this disadvantage.

OSBORN BOTANICAL LABORATORY, YALE UNIVERSITY, NEW HAVEN, CONNECTICUT

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[1] Present address: Forest Pathology Laboratory, Botany Hall, Iowa State College, Ames, Iowa

BRIEF NOTES ON PLANT DISEASES

EXPERIMENTAL FORECAST OF WHEAT LEAF RUST FOR OKLAHOMA FOR 1955

By H. C. Young, Jr. and D. F. Wadsworth

Forecasts of wheat leaf rust (Puccinia rubigo-vera var. tritici) development in Oklahoma have been made for the past 14 years. These forecasts have been based upon the fact that from April 1 through about June 1 weather conditions in Oklahoma, essentially temperature and rainfall or wetting periods, are optimum for the continued multiplication and development of leaf rust. An extended dry period or drought during April, May, or June would be expected to alter development of rust and therefore upset the forecast. Such a condition has occurred only once during the time these forecasts have been made. In 1952, the forecast indicated an expected loss of 7 to 10 percent of the crop, but rust development was halted by a severe hot dry period the second and third week of May. Final estimates of actual loss due to leaf rust that year were somewhat less than 5 percent. In all other years that these forecasts have been issued, either by the present authors or by K. Starr Chester and his associates, final estimates of crop damage have indicated that the forecasts were essentially correct. The principal variable factor, therefore, in leaf rust epidemiology has been found to be the amount of inoculum present over the State at the beginning of the period (April 1).

The amount of inoculum present on April 1 is determined in two ways. Overwintering and early spring development is closely observed at Stillwater, Oklahoma, by periodically counting the number of rust pustules on 1000 tillers of Cheyenne wheat, a susceptible variety. Two to three thousand pustules per 1000 tillers of Cheyenne on April 1 indicates that there will be approximately 5 percent crop loss by harvest time, which has been found to be about average or normal for Oklahoma. These pustule counts are then supplemented by a statewide survey during the last few days in March to determine if the conditions at Stillwater have been representative of the State as a whole. If not, the forecast is adjusted in accordance with the data accumulated on the survey.

This year the pustule count at Stillwater on March 31 was only 12 pustules per 1000 tillers. A 2500 mile survey of the State showed that there was somewhat more rust than this to the east of Stillwater, but practically no rust to the west. Even in the southern part of the State there is much less rust than normal. However, this may be offset somewhat by the delayed condition of the crop, which is 3 to 4 weeks late in most of the central and western parts of the State.

Consequently, the loss to the wheat crop from leaf rust in the 1955 season is expected to be about 1 to 2 percent, considerably less than average.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, OKLAHOMA AGRICULTURAL AND MECHANICAL COLLEGE, STILLWATER, OKLAHOMA

ADDITIONAL NOTES ON RUST OF MERION BLUEGRASS IN NEBRASKA

By W. W. Ray

A severe outbreak of leaf-rust on Merion bluegrass was reported by me in The Plant Disease Reporter 37: 578. 1953. On the basis of urediospores the fungus was identified as Puccinia rubigo-vera (DC.) Wint., although morphological variations of the spores were somewhat puzzling.

Specimens bearing urediospores and teliospores were subsequently sent to Dr. George B. Cummins for examination. In correspondence he stated: "The rust is a small-spored race of Puccinia graminis like all other rusted Merion that I have seen. Your collection has the first telia that have come my way and they substantiate the identification as P. graminis."

The lawn of Merion bluegrass reported heavily infected in 1953 contained only a trace of rust in 1954. However, in Lincoln, another large lawn seeded to Merion bluegrass in the fall of 1952, and which had some rust in 1953, was severely infected with rust in 1954. The owner of the property was very much disappointed with the lawn, but will await further development before deciding to keep, or destroy, it in favor of regular Kentucky bluegrass.

Some Lincoln nurserymen also had rust in their nursery plantings of Merion bluegrass in 1954. These plots were not observed because the matter was not brought to my attention until too late in the season.

AGRICULTURAL EXPERIMENT STATION, LINCOLN, NEBRASKA

CORRECTION

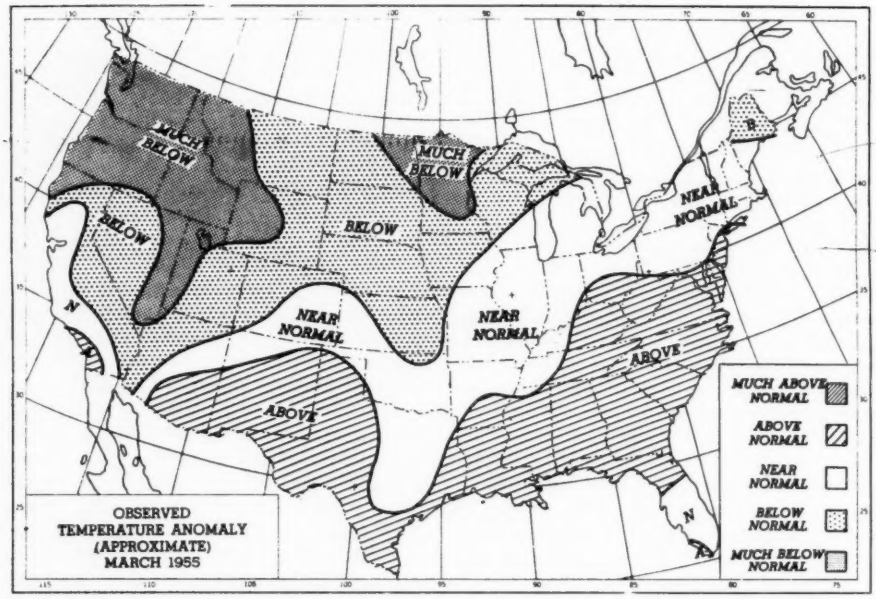
Ustilago bullata Berk. was inadvertently reported occurring in Nebraska on Hordeum pusillum Nutt. (Plant Disease Reporter 38: 586. 1954). The host should read: "Hordeum jubatum L." According to Fischer's "Manual of North American Smut Fungi", Nebraska lies within the range of this smut on H. jubatum, although Nebraska is not listed among the States in which it is reported to occur. -- W. W. Ray, Agricultural Experiment Station, Lincoln, Nebraska.

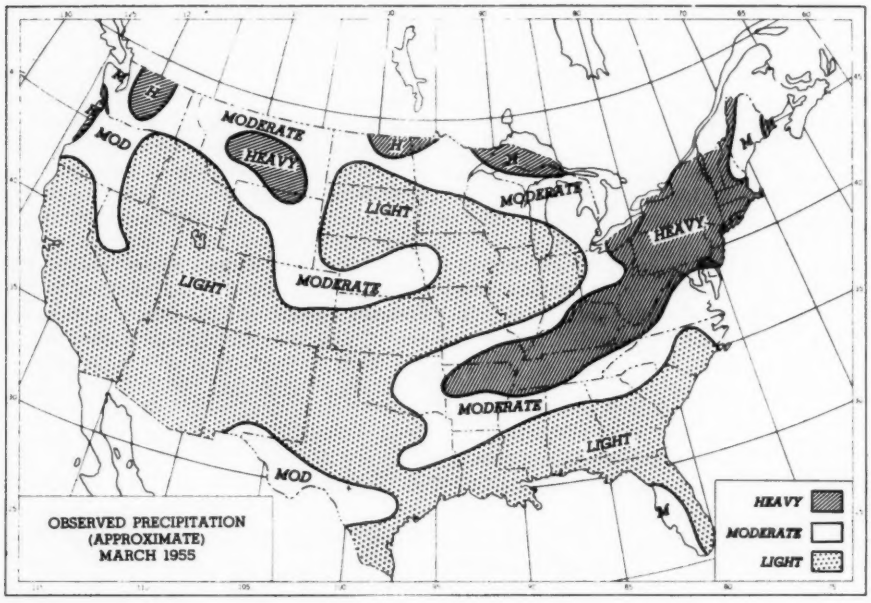
NEMATOLOGY WORKSHOP HELD AT LONG ISLAND, NEW YORK FEBRUARY 14-25

A Nematology Workshop was held at the United States Dept. of Agriculture's Golden Nematode Control Headquarters in Hicksville, Long Island, New York February 14 to 25, 1955 under the direction of Mr. Joseph F. Spears, Project Leader. This training course dealing with plant parasitic nematodes was sponsored by the Nematode Control Project of the Plant Pest Control Branch, Agricultural Research Service, and brought together some 40 Federal and State employees in the New York area concerned with nematode regulatory problems.

The principal subject matter covered in this training course included laboratory techniques used in the preparation of microscopic mounts and the means of isolating nematodes from bulbs, plant tissues and soil. These studies included anatomy, morphology and life cycles and considerable time was devoted to nematode systematics. However, since the personnel who attended this course were employees directly concerned with nematode regulatory problems, particular emphasis was placed on those groups of nematodes with species which have received special surveys or attention from a regulatory viewpoint. Extra time was taken to study the genus Heterodera with such important species as rostochiensis, tabacum, schachtii, and glycines. Another laboratory exercise familiarized employees with the genus Ditylenchus containing the important species destructor and dipsaci. A full period was used to acquaint personnel with the nematode Radopholus similis, a potential threat to the citrus industry. Additional time was allotted to either known or suspected agricultural pests such as species of Meloidogyne, Belonolaimus, Trichodorus, Tylenchorhynchus, Pratylenchus, and Xiphinema.

Instructors for the course were: Mr. A. L. Taylor, Section of Nematology of the U. S. Dept. of Agriculture, and Dr. J. N. Sasser, North Carolina State College. They were assisted by Dr. Victor Dropkin, Mr. George Fassuliotis of the Nematology Section and Mr. Daniel O. Betz, Golden Nematode Control Project. Many of the personnel attending the course were directly concerned with potato problems, therefore, eight hours of instructions were set aside for lectures and demonstrations concerning the principal varieties of potatoes and the diseases and insects that affect them. This phase of the instruction was under the direction of Cornell University instructors: Dr. Robert Dickey, Dr. Richard Sawyer and Dr. Maurie Semel. -- Joseph F. Spears, Golden Nematode Control Project, Hicksville, Long Island, New York.





The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time. Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.

MANUSCRIPTS FOR THE PLANT DISEASE REPORTER

(See also PDR 35: 121-122; 36: 214, 494)

(1) GENERAL: The Reporter page measures 9 inches long with the heading or 8 3/4 inches for the text part, by 6 inches wide. The copy is typed on a larger page, 11 1/4 inches of text or 12 inches overall in length by 8 inches in width, and reduced 25 percent in the photographic process of reproduction. Illustrations or tables larger in either dimension will take a correspondingly greater reduction. Only one size of type is available for text, footnotes, or tables.

(2) MANUSCRIPTS should be the original ribbon copy, not carbons, clearly typed and double-spaced throughout, including tables, footnotes, and bibliographies. (Note -- only one copy is needed.) Footnotes should be typed at the bottom of the page.

(3) ABSTRACTS are requested for all except very short articles. (PDR 38: 316).

(4) CAUSES OF DISEASES should be named. For bacteria, fungi, nematodes, etc., give the Latin name of the organism; for viruses either or both the accepted common name of the virus or a Latin name if you prefer it and there is one; for non-parasitic diseases state the causal factor if it is known. If the cause of a disease has not been determined say so. (PDR 36: 494).

(5) LITERATURE REFERENCES should be given in alphabetical order and numbered for citation in the text. We follow the AIBS suggestion of placing the year of publication after the author's name. Please check your titles carefully since we cannot do it for you. Be sure that text citations and bibliography agree; that foreign-language references are correct; that number or month is cited for periodicals that are not paged consecutively throughout the volume.

(6) NAMES OF FUNGICIDES should be given according to the suggestions that will be published in Phytopathology before long, and later repeated in the Reporter. In the meantime see PDR 35: 122.

(7) ILLUSTRATIONS should be sent to us unmounted. To prevent mistakes, write figure numbers on the back, and mark the top of each print when necessary. A sketch can show a preferred arrangement but please keep in mind page size, shape, and standard reduction (see above under General), and remember that figure titles and legends are part of the page. Lettering should be clear and large enough to be legible after reducing. Drawings, maps, and graphs can be photographs or originals, but should be finished and ready for reproduction, not just sketches.

(8) TABLES should be carefully thought out with particular attention to the Reporter's limitations in reproduction. Make titles and headings definite and self-explanatory. Designate footnotes in tables with superscript lower-case letters. Be sure that text discussion agrees with the data in the table. Do not abbreviate names of crop varieties.

(9) REPRINTS cannot be supplied since there is no way in which we can be reimbursed. However,

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(11) We are the official correspondents in the United States of the PLANT PROTECTION BULLETIN published monthly by the United Nations Food and Agriculture Organization. We would appreciate it if plant pathologists would send us suitable material from time to time for inclusion in our monthly summary reports. Please mark it clearly so that we will know it is intended for the Bulletin. (See PDR 36: 492; 37: 637) -- P. R. M.